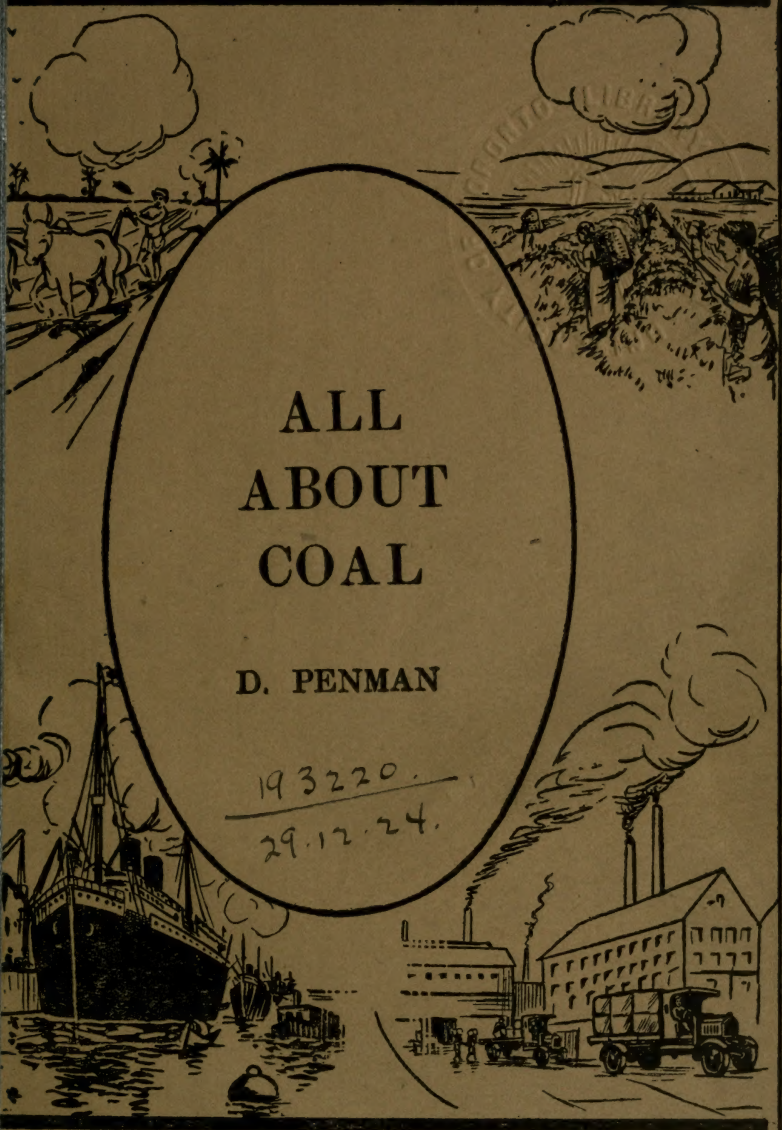
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IA'S GREAT INDUSTRIES



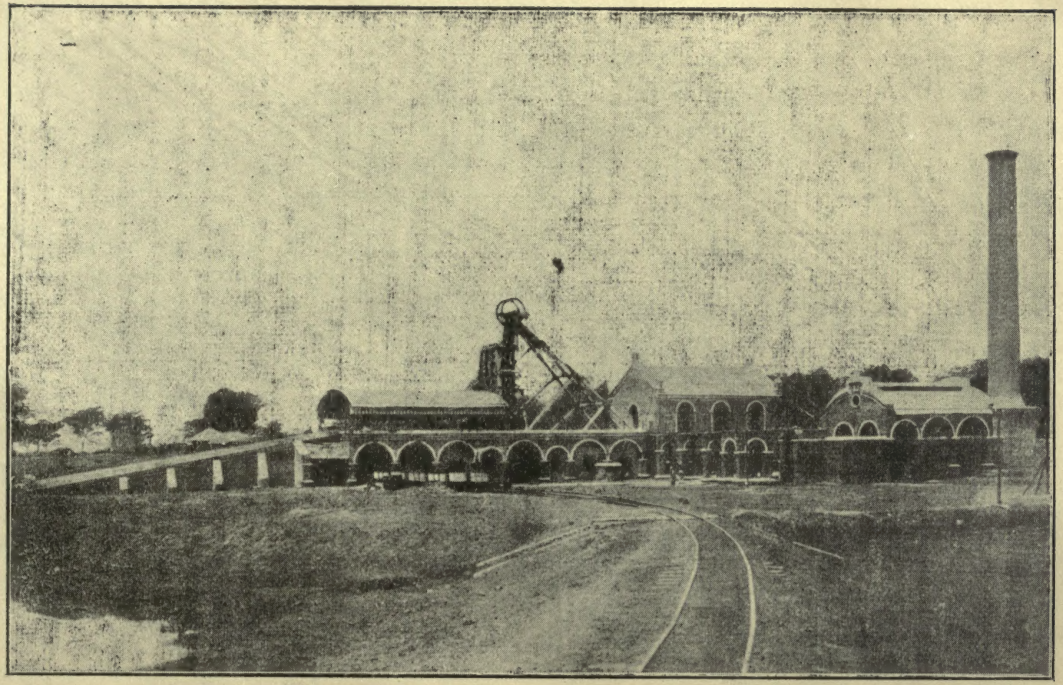
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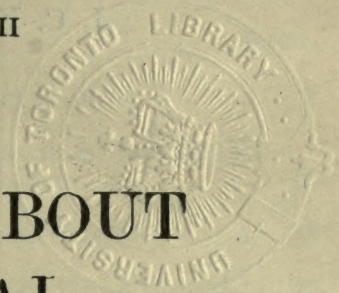
Charanpur Colliery—Raniganj Coal-field, Bengal. On the right is seen the colliery chimney, and in the centre is the winding head-gear.

(By special permission of the Geological Survey of India.)

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INDIA'S GREAT INDUSTRIES

No. II



ALL ABOUT COAL

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Principal, School of Mines, Dhanbad

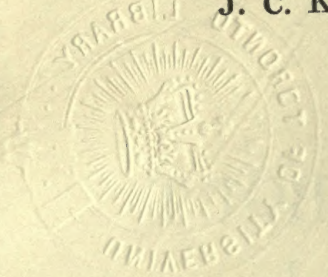
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CHAPTER I

COAL—WHAT IT DOES

We are going to talk about a kind of black rock called coal, which is found in many parts of India. Most of you have seen a piece of coal. It is black and dirty but when set on fire gives out glow and heat which cooks our food and warms our bodies in the cold evenings of winter. But coal does much more than this. How well you enjoy a ride in a railway train. Perhaps you are going to see friends. You get into the carriage not far behind the engine, which puffs and snorts as if it were in a great hurry to get started. Soon you hear the tinkle of the signal to start and the train moves slowly out of the station. The speed quickly increases until you are flying along faster than the quickest horse can travel. What fun to lean out of the window and watch the trees and fields flash past you as if they were chasing each other! But have you ever thought of what it is that makes the engine able to pull such a long train of carriages crowded with people and to travel so fast? Well if you were on the engine itself you would find that all the time the engine is running, and sometimes when it is standing, a man is throwing coal as fast as he can into the blazing furnace beneath the boiler. He must keep the fire well supplied with coal for it is the heat from the fire which changes the water into steam for driving the engine.

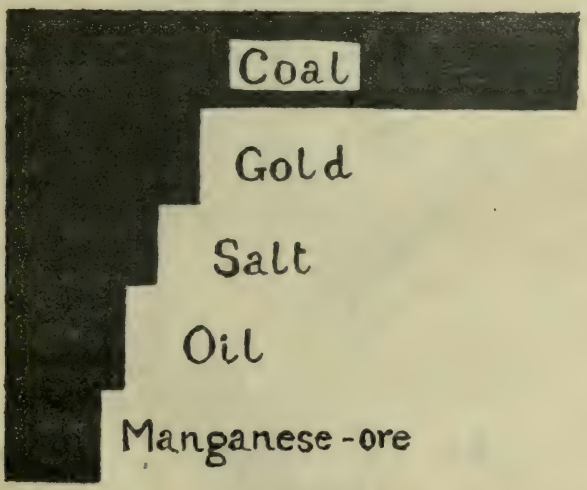
What a powerful engine a railway locomotive is! Just try to picture how many bullocks would be needed to pull a long train of carriages or wagons. Why, it would take hundreds, perhaps thousands, of bullocks to do as much work as a single railway engine; and think of how fast the engine can go. What a weary journey it would be if the only way you could get, say from Calcutta to Bombay, or Madras, was by means of a bullock cart or even a horse gharry. It would take about three months to go on a bullock cart whereas you can go in less than two days in a railway train.

And perhaps you have seen the big steam-ships coming up the river at Calcutta or into the docks at Bombay or Madras. How grandly they move through the water, and glide into their berths! Here again it is coal which provides the power to drive those great vessels through the water. Deep down in the hold of the ship coolies are hard at work keeping the boiler fires fed with coal. Coal is the fuel which drives the railway engine and the steam-ship just as food is the fuel which keeps you alive and makes you grow bigger and stronger. There are many other things which man can do by means of coal.

For instance it is coal which provides the power to drive the machinery in most of our large mills and factories, and to work the tramcars in our large cities. From coal we get our supplies of gas for lights and cooking and we could not make such large quantities of steel if we did not have coal. You will see a drawing on Fig. 23, which shows some of the fruits of coal. Even this picture doesn't show all the things we get from coal. You can see then, that coal is a most valuable rock, and, if you follow your lessons in geography and history carefully, you will find that most of the great countries of the world owe their position amongst the nations of the

earth chiefly to their having had large quantities of coal within their boundaries.

Now, you will all agree that India is a great country and you all feel that you would like to see your beloved land becoming greater and greater. One of the things that makes India an important country is the size and value of her coal fields. Of course there are other things that make India a wonderful country even without coal, but coal is so useful that you will agree, I think, that the value of India to herself and to the world is greatly increased by there being large quantities of coal in the country. That being so it is surely right and proper that you as sons of India, should take a deep interest in one of her most valuable possessions. It is for this reason, that this little book has been written. That coal is the most valuable as well as the most



Value of Coal. The heights of the columns show the valve of the coal produced in India compared with other things It will be seen that coal is easily the most valuable. Fig. 2.

useful mineral found in India you can see from Fig. 2. In the book you will learn what coal is, where it is found, how it is got out of the earth, the dangers that beset the miner in his work, and many other interesting things about this most useful and valuable mineral.

CHAPTER II

COAL—WHAT IT IS AND WHERE IT IS FOUND

Coal is found in the ground with other rocks below and above it. It differs from the other rocks in that it burns easily and gives out great heat. It is found in layers or leaves as shown in the drawing Fig 3. In the drawing, you see a layer of coal

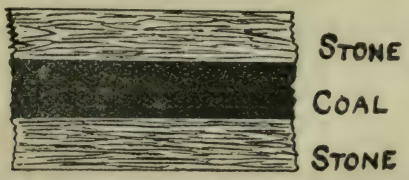


Diagram showing coal-seam Fig. 3.

between two layers of rock just as if you placed three books on the top of each other, the book in the centre to stand for a layer of coal. The miner does not speak of a "layer" of coal. Usually he calls it a "seam" of coal. Sometimes the seam is quite thin, only a few inches thick but sometimes it is very thick as much as a hundred feet. The coal-fields of India are famous for the great number of thick seams which are found in them.

The coal seams are not always lying flat, indeed they are very seldom quite flat except for short

distances. They are more often found to slope as in the drawing in Fig. 3a. If you take the three books

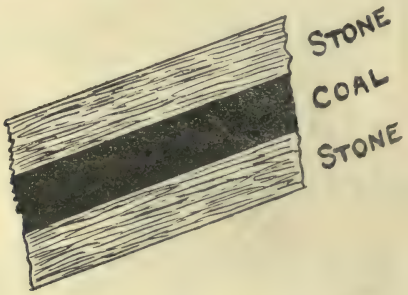
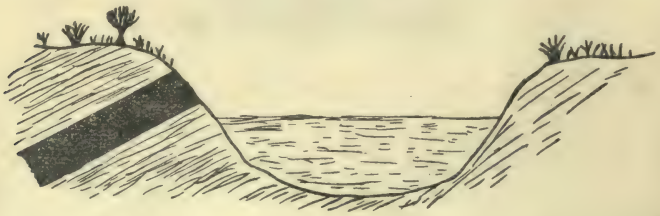


Diagram showing coal-seam. Fig. 3a.

again, first place them flat on a table and then turn them up slightly on edge you will see what the drawing means.

When a coal seam slopes like this you can easily understand that it will come out at the surface somewhere as is shown in Fig. 4. The part of the



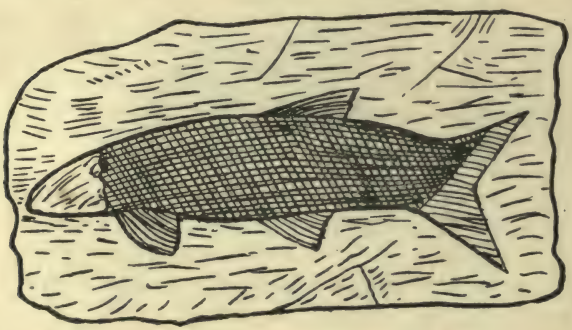
A coal-seam appearing on the bank of a river. Fig. 4.

seam which appears at the surface is called the "outcrop" The outcrop is sometimes easily seen especially along the banks of a river as in Fig. 4. However the outcrop is often covered over with soft earth so that it is hidden. Even in such cases the miner is often

able to find out whether there is coal underneath the surface of the ground. He may notice that a strip of the ground is darker in colour than the rest due to there being small pieces of coal mixed with the earth and he may even be able to pick out quite large pieces of coal. You can easily understand that when the miner sees bits of coal lying about in a place where no coal is being used or laid down he is not long in trying to find out if coal actually exists underneath the surface. He may then start to remove the covering of earth to see if there really is coal below.

The one man above all others who is of most use to the miner in finding out those parts of the country which contain coal is the geologist. A geologist is a man who knows all about the rocks forming the crust or skin of this old world of ours. He knows just the kind of rocks in which coal is likely to be found. You must know of course that coal is not found everywhere. It is really only found in patches here and there. Some of the patches are many hundreds of miles apart and no coal is found anywhere between them. Why is this? Well the geologist tells us that at certain times in the history of the world dense jungles grew near where coal is now found. The leaves and other parts of trees and plants were carried by rivers and streams into quiet lakes or seas and there fell to the bottom. Through time the layer of woody matter and mud at the bottom of the lake grew to be very thick. After a time the rivers would bring down large quantities of mud and sand which would cover up the woody material. Then perhaps more leaves and bits of trees would settle in the lake forming another layer of vegetable matter. This would be covered up in turn by mud and clay and so through many years the process would go on until the lowest layer of leaves

would be a long way below the top layer of mud. Sometimes casts of plants and fish are found in the rocks. These are called fossils, Fig. 5. If you wish to see how the mud and other things settle to the bottom in water just take a glass of



A fossil fish. Fig 5.

muddy water, place it on the floor or the table, and watch the mud falling to the bottom. Now after thousands of years those layers of leaves, and clay, sand and mud became hardened from various causes into solid rocks, the vegetable matter being changed into coal. If you were to dig a deep hole in any of the Indian coal-fields—and this we shall see is just what the miner does when he wants to get down to the coal—you would come on layer after layer of coal just as if it had been laid down in the way I have described. Fig. 6 shows you how the seams of coal in an Indian coal-field are found on the top of each other; and you would find the same thing in every coalfield in the world.

There is another way in which it is believed coal seams have been formed. The trees and plants died and decayed where they grew. New plants

and trees would grow up in their place and these in turn would die and add to the heap of decayed plants on the ground. Go into any jungle in India and you will find this sort of thing going on to-day.



A mine shaft passing through several seams of coal. Fig. 6.

You will find the ground covered with a thick layer of decayed and decaying vegetable matter. Well after a time the jungle became covered over with water, perhaps forming a large lake. There would

be streams running into this lake, the streams would bring mud and clay, the mud and clay would settle to the bottom of the lake and cover up the layer of decayed plants. Then as the years rolled on the vegetable matter would gradually become changed into coal.

If you have understood what you have been reading you can easily see that all the layers of vegetable matter would not produce the same kind of coal. Some layers have been longer in the ground than others. The plants have been changed into coal slowly and thus in some layers the process has been more complete than in others. Besides all coal has not been formed from the same kind of plants. So, because of all this, we have different kinds of coal. *Anthracite* is the most perfect form of coal, *Bituminous* coal comes next, and then *Lignite* coal which is the poorest kind and looks like charred wood. The coals found in India are chiefly Bituminous and Lignite. Anthracite coal is not worked in India. Moreover the coal seams will not be all of the same thickness, because some of the layers of leaves would be thicker than others.

Another thing that you can well understand is that as the decayed plants would be mixed with particles of mud, the coal is not found pure. The particles of mud remain as ash after the coal has been burnt.

The coal seams were all laid down first of all on nearly flat ground, but owing to movements of the rocks such as earthquakes, etc., they are now found at all angles from flat to vertical. This is fortunate for the miner because as we have shown at the beginning of this chapter, a sloping seam is bound to come out at the surface and so it can be easily discovered. Sometimes the miner drills a vertical hole called a bore-hole from the surface down through the rocks in order to find out the number and thickness of the

coal seams which lie below. Many of the coal-fields of India have once been joined together but movements of the earth and the wearing effects of time have rubbed out, as it were, large portions of ground which once contained coal. There is plenty of coal left in India however to supply all our wants for many years to come.

The coal-fields of India are estimated to contain 79,000,000,000 (seven thousand and nine hundred crores of tons of coal.) The output of coal for the whole of India at the present time is about 20,000,000 (two crores) tons. It will not be possible to take out all the coal but if we suppose that one-fifth of it can be got—that is about 15,000,000,000 tons—you can see that we can go on digging coal at the present rate for 700 years to come! Of course we hope that the output of coal in India will increase very greatly. But even though it should increase to say ten crores of tons a year there is plenty of coal in the country to do for at least one hundred and perhaps two hundred years, and that is quite a long time to look a head. At present the Jharia coal-field—in the province of Bihar and Orissa—produces more than half of the total output of Indian coal. The Raniganj field in Bengal is the next largest producer. These two fields, together, produce over nine-tenths of our coal production. There is no saying, however, but what other fields may grow rapidly in the near future. Indeed some are sure to do so sooner or later. Coal is also got in Assam, Burma, Punjab, Beluchistan and Hyderabad.

CHAPTER III.

THE MINER AT WORK.

Let us now visit an actual coal mine and see the miner at work. We will first go to an "open cast" mine or quarry. We have seen that the coal seam comes out at the surface of the ground. When this is the case the miner simply removes the earth on the top of the coal and digs the coal out. Fig. 7 is a



Women carrying coal out of a quarry. Fig. 7.

photograph showing the appearance of a quarry. After a time more of the top cover is taken away so

that more coal may be dug out. You can see that after a time the cover of earth and rock will become so thick that it will cost too much to pay the miner to remove it. What does he do then you wonder? Well the next three drawings will show you exactly what he does. He does not take out all the coal any longer but only part of it. He leaves in square blocks callled " pillars " of solid coal to carry the weight of the rocks over head. Fig. 8 shows the appearance

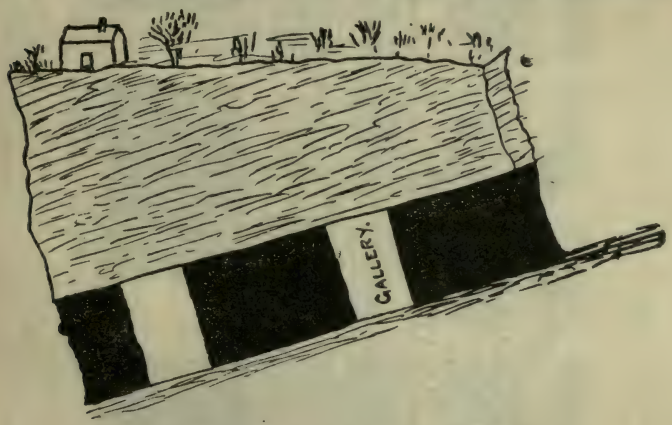


Diagram showing galleries and pillars of coal. Fig. 8.

of those pillars going down hill into the mine and Fig. 9 shows how they look if we stand on the other side of the quarry and look along the face of the workings. The two pictures are nearly the same except that one shows the pillars along the level and the other shows them on the slope. If you were to remove the whole of the cover of rock or if you could lift it up like the lid of a box, the pillars and openings (called galleries) would look like the drawing Fig 10. The pillars are seldom perfectly square. Let us watch the miner at work for a little. His chief

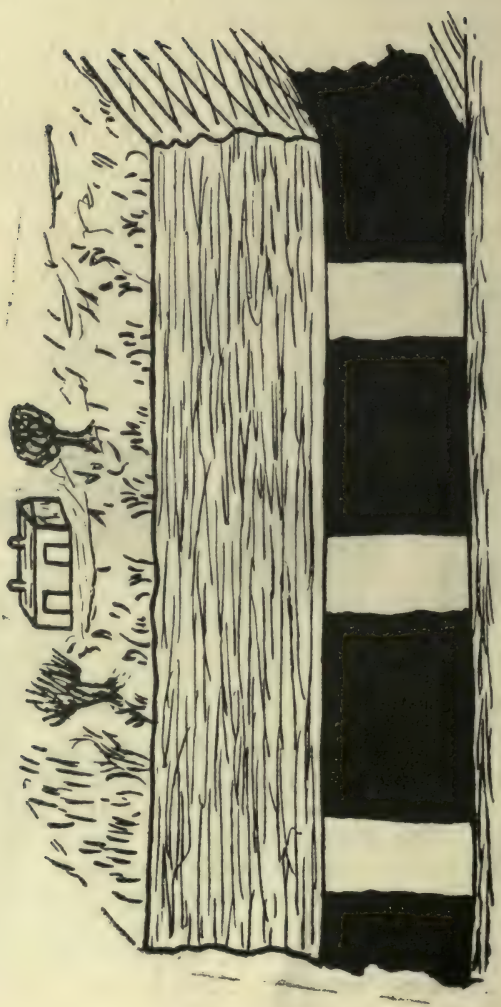
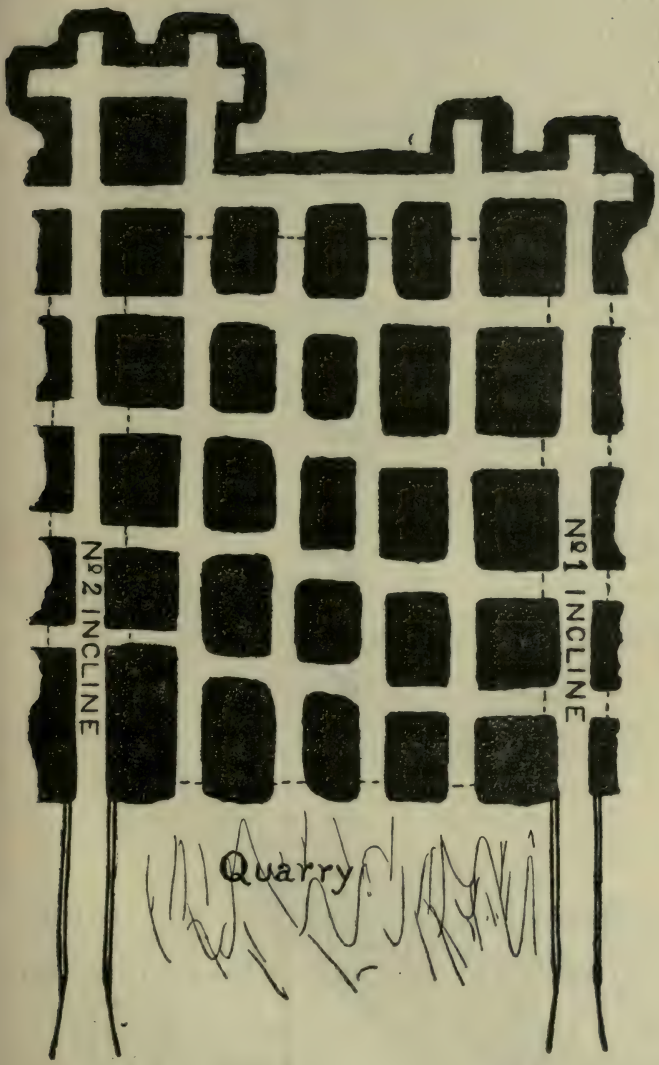
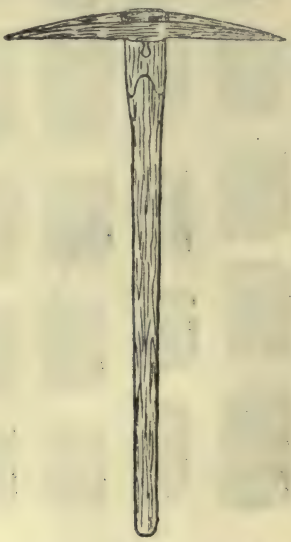


Diagram showing galleries and pillars along the face of a quarry. Fig. 9.



Underground workings in a coal-seam showing galleries and pillars of coal. Fig. 10.

tool is a pick shown in the drawing Fig 11. The blade is of pointed steel and it is fixed on a wooden handle nearly three feet long. The miner wears nothing but a loin cloth. His work is very hard and he is in a warm climate so that to wear as little clothing as possible is the proper thing. He swings his pick over his shoulder and brings it down on the coal with all his force. The sharp point pierces the coal and acts as a wedge and by a twist or jerk



A miner's pick. Fig. 11.

of the handle he dislodges a piece of coal. The miner soon learns the best place to strike the coal for he knows that it is got more easily one way than another. Sometimes he uses a steel rod called a crowbar or sobel to loosen an extra large piece of coal when he has prepared the way for it by means of his pick.

Sometimes he makes use of explosives such as gunpowder or dynamite to dislodge the coal. He drills a narrow hole into the coal about four feet deep, puts some explosive in it, and warning everyone to retire to a safe place he lights the "fuse" which sets off the charge. The fuse takes a good many seconds to burn so that he himself has time to get to a place of safety. The "shot" may bring down large blocks of coal. When the coal is loosened and broken into small lumps if necessary, it is loaded into baskets. Women—called kamins—or boys generally do this work. The women carry the loaded baskets on their heads. Just watch them and see how steadily and even gracefully they walk with their load. (Fig 7). Try to lift a full basket of coal. You will find it is a good weight. The baskets are emptied on a level piece of ground close to the quarry. The coal is laid down in flat heaps about 1 foot high. The miner in this case is paid by quantity, not by weight. He is paid a certain sum for each heap so that he knows his wages just by measuring the size of the heaps belonging to him. Sometimes the coal in the heaps is white-washed. This is done in order to be able to detect stealing.

When what is called the surface coal has all been got and the workings go deeper and deeper under the ground the miners do not use all the openings to the surface. They may only use two or three and block up all the other outlets or fence them off. If you look again at the picture in Fig 10 you will see that there are two rows of galleries marked "inclines" no. 1 and no. 2. The other openings are fenced off. This is shown by dotted lines. The Indian Mines Act says that there must always be at least two outlets from the mine. Another rule says that openings which are not in use must be fenced off. These rules are made to protect the miner.

If there was only one outlet from the mine, picture to yourself the state of the poor miners if that one outlet should become blocked. They would be caught like rats in a trap. Many things might happen to block a gallery. The roof might fall down and fill the gallery with great blocks of stone. This often happens in a coal mine. You will see in another part of the book how the miner tries his best to keep the roof from falling. Or a big fire might take place on the single outlet. This is not imagination, for quite a number of the coal mines in India are on fire. One can hardly bear to think of the fate of the poor victims of a fire in a mine. We will learn more about this presently. So you see that it is a wise rule which says that there must be at least two ways of escape from the mine. And it is just as wise to state that the roads which are not required must be fenced off. The unused roads are not examined and may not be safe, and so it would be dangerous to allow the miners to go into such places.

Sometimes an entire family of miners works together in a gallery. The husband is the pick-man or "coal-cutter" as he is called. The wife carries the coal and if they have a son or daughter old enough to be able to work they may also help to get the coal. As we have said, the miner is paid by the quantity of coal he cuts and so a family can easily work together, the wages for all the members being paid as for one.

Sometimes even little children are brought into the coal mine. Their mothers and fathers often like to bring their children with them rather than leave them perhaps alone at home. The children don't do any work of course, they usually sleep most of the time and you need not think that the mine is a bad place to sleep in. Most parts of the mine can be made perfectly safe, and the air is often nearly

as fresh and sweet as on the surface. Besides one is away from the hot glare of the Indian sun. Sometimes the miner has his bed with him and he or his wife or the children may rest and sleep quite comfortably and safely. Of course it would be much better if the mother and her children stayed at home. It is not good for the home life or the children that the mother should have to go and work. The father should be the breadwinner. The day is not far distant, we will hope, when women and children will be no longer found at work in the mines. Care must be taken that there are no loose stones or coal hanging from the roof or sides of the galleries. Not long ago three poor people were killed by a fall of coal from the side of a pillar. They had been working hard and feeling tired, had lain down on the floor and fallen sound asleep. But alas ! they had not examined the place to see if it was safe. A large block of coal slipped off the side of the pillar and killed all three. Usually a coal mine can be made quite safe but it is never entirely free from danger. We shall learn more about the dangers of the mine in a later lesson.

In the larger collieries contractors are employed to cut the coal, bring it to the surface and load it. These contractors in there turn employ a number of miners, men, women and boys to do the work. As we have already seen the men cut the coal and the women and boys load it. The contractor makes a *bundobast* with the company owning the colliery and he then pays the workers whom he employs.

CHAPTER IV.

THE MINER AT WORK (contd.)

We have seen that the miner leaves in part of the coal to keep up the roof.

There is a method of taking out all the coal in a seam in one long line but this method is not much used in Indian mines. Most of the coal seams in India are too thick for it to be easy to take out all the coal. Besides the miner likes to see something solid left in to hold up the roof.

Let us look again at the miner at work. In making the galleries, the miner first of all cuts a narrow hole in advance of the rest of the working "place". He may then cut down the coal still remaining in the roof up to the stone. Then he digs out the floor coal, which is easier to get than any. Sometimes he has to cut coal off the sides of the pillar. By this time the gallery may be very high, anything up to 35 feet high. To get down the coal on the sides of the pillars the miner stands on stools or ladders. Sometimes the sides which may have been quite hard for a long time get loose. Overhanging coal of this kind is very dangerous and until it is taken down, anyone coming near is running a great risk of being killed. We have mentioned a case like this in Chapter 3 and such accidents happen all too often in Indian Mines. The miner has to be very careful himself when taking down top and side coal. He must see that his ladder or stool is clear of any large block

of coal that may come away as he cuts it down. He knows whether the coal is loose by striking it with a long bamboo pole shod with iron. If it sounds "hard" it is quite safe but if it sounds "loose" it must be taken down at once.

Sometimes the miner has to put in "props" to hold up the sides and the roof. (Fig 12). If the roof



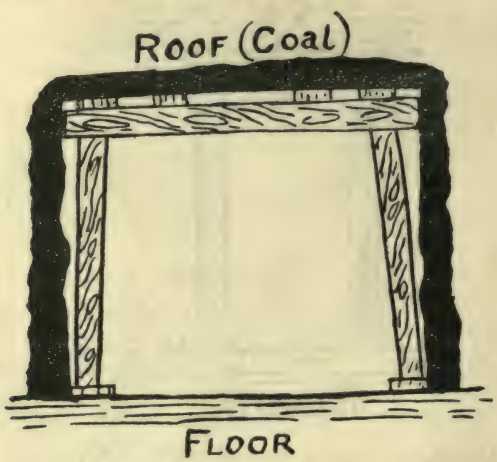
Supporting the roof with wooden props. Fig. 12.

is very weak and soft he may have to put up strong wooden beams or steel girders resting on brick walls. (Fig 13).

The amount of coal left in the pillars is very great. The miner does not care to lose all this valuable coal so he tries to take out the pillars as well as he can. Sometimes he takes out a pillar completely, a bit at a time. While doing this the roof is held up by means of props placed very close together.

Then another pillar may be removed. Great care must be taken in removing a pillar. It is

a very dangerous undertaking, especially if the seam is very thick, as most seams are in India. The roof is certain to fall down sometime or other for the props cannot bear the great weight of the roof for long and the miner has to be constantly on the alert for signs of danger. If he thinks that it is too great a risk to take out the entire pillar he removes a portion of it either by driving galleries through it or by taking coal off the sides of the pillar. It is a



Supporting the roof with beams. Fig. 13.

common practice for some miners to cut coal from the sides of the pillars against the orders of the manager of the mine. This sort of thing is called "robbing" the pillars. The coal cut from the sides of pillars is very easily got, and as the miner is paid for the amount of coal he digs, you can easily understand that it is a great temptation to him to "rob" pillars in this way. But the practice is a very dangerous one. Many accidents have taken place as the result of miners robbing pillars.

They go often into places which have been fenced off just to get loose coal from the sides of pillars. These places are not examined and are often unsafe. Yet the miner will run the risk of being buried under a great fall of coal just for the sake of getting coal which is easy to cut.

Sometimes the pillars are "robbed" to such an extent that they give way under the great weight of the roof. If it is meant that this should be done and great care is taken to avoid accidents the only bad feature about the collapse of the roof of the mine is that the surface is badly disfigured. If you go into almost any coal mining district in India you will see many places where the ground has fallen in, due to under-mining.

If pillars are taken out below a village the people must be removed before the ground is allowed to collapse or else there may be a bad accident. One very tragic event of this kind is on record. Galleries had been driven under a village and it was then decided to split the pillars by cutting other galleries in two directions at right angles through them. This divided each large pillar into four small pillars called "stooks." The galleries were to be not more than a certain width, and it was thought that the stooks would be strong enough to hold up the roof. But the miners "robbed" the pillars in the way we have mentioned above, and one night the roof collapsed over a very wide area.

On the surface there were three rows of miners huts or dhowras. One row was outside the collapsed area and was untouched. The middle row went down vertically with the falling ground and not one of the people in the houses was hurt. But alas the third row was completely wrecked and 7 men, 9 women, and 8 children who were fast asleep when the ground collapsed were killed.

What a tragedy those miners had caused through "robbing" pillars against orders! Miners who do this sort of thing deserve to be punished and if they are found out often are punished.

The miner is not allowed to take out all the coal below railways as if he did so the railway might be completely wrecked. He may drive galleries through the coal below the railways but the galleries must be narrow and the pillars big and strong enough to prevent any movement of the ground over which the railway passes.

In most cases the miner finds it very difficult indeed to take out all the coal. In England where the seams are not nearly so thick as those in India, the miner often takes out all the coal in one long line. He does not drive galleries and leave pillars but takes out all the coal as he proceeds. The roof is kept up by timber and by packing the space left by the coal with stones and other rubbish. This method cannot be used in India because of the thickness of the coal. The miner can only take out about half of the coal at first leaving the other half in the pillars. Some of the remainder he may get out but it is very difficult to get it all.

To leave in valuable coal is to waste the resources of the country, however, and mining engineers have tried and are still trying to find some means of getting out all the coal or at least the most valuable parts of it.

One of the methods of doing this is the system of "sand-packing." In this system the miner fills in the space with sand as he takes out the coal. The sand is brought from the nearest river, and is carried into the mine through pipes by means of water. The water drains off and is pumped out of the mine. The sand packs very closely and if the space left by the coal is filled solid the roof is held up almost as well as by the solid coal itself. The miner may take out

the coal in the ordinary way by driving galleries which are then filled in solid with sand and the pillars of coal afterwards taken out. The spaces left by the pillars are also filled with sand. In this way a "seam" of sand slowly takes the place of the seam of coal. Another way is to take out the lower part of the seam, completely filling the space with sand as the work goes on, and then afterwards to take out the upper portion with the compressed sand as a floor.

Other kinds of material besides sand are used for this purpose, although sand is perhaps the best, if there is plenty of it at hand.

Not only does sand packing enable the miner to get more of the coal out of the mine but it completely prevents the roof from collapsing, which we have seen is the cause of many accidents. There are now quite a number of mines in Bengal and Bihar and Orissa where this method of sand-packing is used.

CHAPTER V.

A MINE SHAFT.

Sometimes the coal lies so far below the surface of the ground that it is better to put down a vertical hole called a shaft to reach it than to make a sloping tunnel from the surface. There are many such shafts on the coal-fields. Another good point about the vertical shaft is that it passes through seam after seam of coal as it goes deeper. You can see this if you look again at Fig. 6 in chapter 2. Some of those shafts are very deep, as much as 1500 feet, but most of them are much less than this. When the top coal seam is reached the miner can start to dig out coal ; or he may wish to work one of the lower seams first. Sometimes he arranges to work two or more seams at once. When he does this he leaves pillars to hold up the roof in all the seams. The vertical shaft has still another advantage and that is that there is coal all round it. The miner can therefore take out the coal in all directions.

At this stage, you may well ask how does he carry the coal to the surface where the outlet is a deep vertical hole or again how does he himself get into the mine ? Does he use a ladder to get to the top ? Oh : no, the miner has a better method than this. You can well understand that it would be a slow and dangerous task to climb up a ladder carrying a basket of coal. What the miner does is this. He makes an iron box called a cage. It is not closed in all

together but is open at the ends. The cage is fixed to a long steel wire rope called the winding rope which passes over a wheel fixed on a frame set over the top of the shaft. The other end of the rope is fixed to a drum which is just a kind of wheel wide enough to hold many turns of the rope. The drum is worked by a steam engine or an electric engine. If you look at the drawing Fig. 17 you will see how the cage is raised or lowered as desired When the engine is set in motion the rope is pulled into the engine-house and coiled on the drum and the cage is raised. If the engine is "reversed", as it is called, the cage will be lowered into the shaft. There are generally two cages, each with its own rope but both ropes are on the same drum and there is only one engine. One cage is being lowered while the other is being raised.

The next question that you might ask is "How is the coal loaded into the cage?" Well it might just be filled as you would fill a basket or a box and then emptied at the surface. This is not the usual way however. It would be too slow, besides being costly. The method used is as follows :—The coal is first of all loaded into boxes with wheels running on rails just like a railway-wagon but much smaller. The women in the mine empty their baskets of coal into these boxes. The boxes are then pushed or pulled to the shaft bottom and run on to the cage in the shaft. The cage is now raised and when it reaches the top of the shaft the box of coal is pulled off. The box is now pushed to the edge of the pit-bank or heap and tipped on its side so that the coal simply falls out.

The miners themselves get into and out of the mine by means of the shaft cage. Let us descend the shaft and see how it feels to go down into the bowels of the earth. As we are not actually working in the mine we must first of all get the permission of the manager

of the mine. The manager will most likely be quite willing to let us go down the mine. If he is not quite sure that we can take care of ourselves while in the mine he will get one of his headmen to go with us. He may even take charge of our party himself. Suppose then that we are all ready to step on the cage at the top of the pit. We notice that three is a fence all round to prevent people from falling down the shaft. At the ends where the cages are entered or left, the fence is formed of gates which are opened by the cages. When one cage comes to the surface it raises the gates on that side, while the gates on the other side are closed because the other cage is at the bottom of the shaft.

The man in charge, called the banksman—signals to the "Onsetter" at the bottom of the shaft and the engineman that men are about to descend. The return signals showing that all is ready are given and now we step on the cage. If we are tall we may have to stoop a little to keep from touching the roof of the cage. There is an iron bar fixed to the roof which we are told to grip firmly. The signal to lower is given. At first the cage descends slowly but soon the speed increases until it is falling at a great rate. We have a funny feeling as the cage drops. We gasp for breath and feel as if our hearts were coming up into our mouths. This feeling soon passes however. The cage sways a little and we have to grip the handle bar tightly so as not to fall. There is a "gate" across the cage but it is only a piece of chain and as there is a foot or two of space between the cage and the side of the shaft, it is quite possible to fall out of the cage and down the shaft.

In one case not long ago a man fell out of the cage to the shaft bottom and was killed. The cage had been swaying a lot and he had loosed his grip of the handle-bar and so fell out. Some years ago an acci-

dent of the same kind happened in a shaft. The man dropped over 270 feet but fell into water. He was rescued and is alive and well to this day. Almost a miracle wasn't it ?

The cage is not allowed to swing loosely in the shaft. It runs on guides which keep it from swinging too much. All the same it always swings a little and we must keep a firm grip of the handle-bar so as to be safe.

We will have reached the shaft bottom long before you have read down to this point, for it takes less than a minute for the cage to travel down the shaft. The cage is slowly brought to rest, the chain "gate" is opened and we step off the cage on to the solid ground. It is very dark and although we have lamps (*batties*) we find it difficult to see clearly for some time, till we get what the miner calls our "pit eyes." The darkness is very dense, much blacker than the darkest night on the surface, for no ray of light ever reaches those underground dungeons.

We will learn however how the mine is lit in another chapter. Just now we want to mention some more interesting things about the mine shaft.

The sinking of the shaft takes a long time. It often passes through very hard rocks which cannot be dug out by the miner's pick alone. He has to use explosives to loosen the hard rock. Then sometimes he has to use bricks and mortor to make soft parts of the shaft sides secure. When he is doing this he works on a platform carried by ropes hung from the surface. The platform can be raised and lowered as desired. While the shaft is being sunk a steel bucket called a "sinking kibble" is used to raise the broken stone and water out of the pit and to lower the bricks and other things that are required. The "Sinkers" themselves also go down and come up in the kibble. (See Fig. 18.) The cages of which

we have been writing in this chapter are fitted into the shaft after it has reached the coal.

When you are going down the shaft in the cage for the first time you must have had such thoughts passing through your mind as, what if the rope should break? or what if the engineman cannot stop the cage in time and it dashes against the shaft bottom?

Some miners, you know, will not trust themselves in a cage. They look at the thin steel winding rope and liken it to a thread which can be snapped by the fingers. They are so afraid that the rope will break when they are on the cage, that they prefer to go up and down the shaft on ladders fixed to the side of the shaft. But they forget that the rope though thin is made of the very strongest steel. The rope used, too, is always much stronger than what is actually required to bear the weight of the cage and its load. For instance if the cage and its load weigh 1 ton, a rope that can bear 10 tons is used. So that you see the rope is really very safe. Of course the rope does break sometimes, for although it is very strong when new, it becomes much weaker after being long in use, just as a shoe lace which was strong at first is easily broken after a few months wear. But if proper care is taken to keep the rope in good condition and to take it off before it gets too weak and put on a new one, it is found that a rope breaks very very seldom indeed.

Now and then accidents occur through the cage dashing against the bottom of the shaft or in the case of the up-coming cage, through it dashing against the pit head frame at the surface. Sometimes this sort of thing is the fault of the engineman, but sometimes it is due to some defect in the engine itself.

The engineman is generally a very reliable man and makes very few mistakes. A rather funny story

is told about one man who wished to be an engineman. He was being given lessons as to how to drive the engine and after a time he was allowed to run the engine without help. He got the engine started all right but as the winding drum began to turn more and more quickly and the noise of the engine and the hiss of steam grew louder and louder he lost his head completely and shouted to his instructor to come to the rescue. The other man, who was a good engineman promptly took control, shut off the steam, applied to brakes and managed to bring the engine, drum, and cages to rest just in time to prevent a bad smash.

Of course in this case there were no miners on the cages so that there were no lives at stake but there might have been serious damage to property. The man never tried to drive a steam winding engine again.

CHAPTER VI.

LIGHTING THE MINE.

Where the miners work in an open quarry they have the full light of day to work in, but in the underground parts of the mine there is perpetual darkness. In order to see to work and to avoid danger the miner must have light. The commonest form of lamp used is a tin vessel burning oil carried on a long piece of wire hooked at the end. Fig. 14. By means



Common miner's lamp. Fig 14.

of the hook the lamp is carried or hung up near where the miner is working. Another form of a similar kind but larger is also much used.

Officials of the mine use a type of lamp burning acetylene gas. The gas is made in the lamp itself simply by the action of water dropping on a chemical called calcium carbide. The gas escapes through a very small hole where it is lit. The flame is white and gives a brilliant light. The flame has a shield which acts as a reflector and throws the light well out in front so that one is able to see quite well.

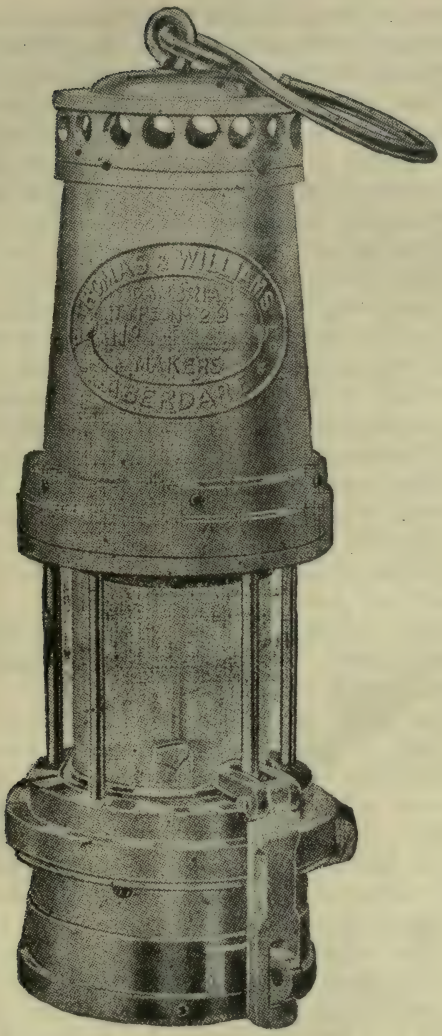
There is a special type of miners lamp well-known to miners in all parts of the world but not so much used in India as in other countries such as England. This lamp is called a safety lamp, that is to say it would be safe to use this lamp where it would be highly dangerous to use any other form of lamp. You may be surprised to learn this and you will find that the history of the safety lamp forms a very interesting story. In many mines in England a very explosive gas comes off from the coal. This gas mixes with the air and if a light were put to the mixture there might be such an explosion as to wreck the whole mine and kill everyone in it. The miner calls this gas "fire-damp."

Well the miner soon found out that it was dangerous to use an ordinary open flame lamp where fire-damp was found and so, clever men tried to make a lamp which would be safe to use even with fire-damp in the air. One of the first things that was tried was a simple machine worked by hand which gave off a shower of sparks. This machine was called "Spedding's Mill" after the name of the inventor. But the light given by the "mill" was very feeble indeed and the miner could not do much work with it. Besides it was found that the sparks were not safe, for sometimes the gas caught fire from the sparks.

At last a real safety lamp was made. The man who did more perhaps than any other to solve this problem was Sir Humphrey Davy. His lamp was called the Davy lamp. There were many other inventors however who helped in the task and kept producing lamp after lamp, each one safer than the one before it until now we have a lamp to give to the miner which is very safe indeed.

An amusing story is told about one of those early inventors. He had tested his lamp many times in a mixture of gas and air and found that it did not ignite the gas. So he went into a mine carrying his lamp in his hand. A miner at work with a shower of sparks close by him, saw the light in the distance and shouted at the top of his voice "Put out that light, are you mad." But the light kept steadily advancing. The miner shouted more angrily than before, but again without avail. The light was getting very near now and the miner, hoarse with passion, cried "If you don't put out that light, I'll drive my pick into you." But the inventor only answered quietly "Keep calm, man, you have nothing to fear."

It took some time however to convince the miners that a real safety lamp was produced at last. Fig. 15 shows a modern miner's safety-lamp. The most important part of the lamp is the gauze. It is shaped like a cap and is built up of thin iron or copper wires crossing each other. The air passing into the lamp to feed the flame must pass through this gauze. If the air should contain much gas there will be an explosion inside the lamp, but the flame cannot pass through the gauze because the gauze has the power to cool it down and so put it out. An explosion inside the lamp would harm no one but if the flame got outside the lamp it might cause a very big explosion. The



Miner's safety lamp. Fig. 15.

gauze has to be cleaned every day and care has to be taken that there are no holes in it. What is more important still the miner must make sure that the lamp has not been put together without the gauze. With some safety lamps it is possible to do this and as the gauze is inside a steel case or shield one might not notice whether or not the gauze was in place unless one looked for it carefully. A miner was being examined to see if he was familar with the safety lamp. He was handed a lamp and asked to examine it to see if it was safe to take into the mine. He looked all over the lamp and after a time said that he thought it perfectly safe. The examiner asked, "What is it that makes the lamp safe ?" The miner answered "The gauze, " "Well" said the examiner, "are you sure that there is a gauze in that lamp ?" The miner peered up through the glass into the interior of the lamp and at last said that he could'nt see the gauze. "No" said the examiner "there is no gauze in the lamp," Needless to say the man did not pass the examination.

The latest mining rules in Great Britain state that the lamp must be so made that it cannot be put together without the gauze.

Another good point about the miners' safety lamp is that by means of it the miner knows when there is firedamp in the air before there is enough of it to cause a big explosion. If he wants to test to see if there is firedamp in the air, he pulls down the flame of his safety lamp until it is quite small. If this gas is present, a pale blue "Cap," as it were, will be seen fitting over the ordinary oil flame. In this way the miner knows when danger is present and gets to a place of safety as soon as he can ; for you must not think that the miner stays in a place where there is a lot of firedamp. If he did even his safety lamp might not save him. For all he knows

some part of the lamp might be out of order. So as soon as he knows that there is firedamp in the air, he retires until the gas has been cleared out. As we shall see in another chapter, firedamp is found in quite a number of coal mines in India, and in those mines safety lamps are used.

Until a few years ago the ordinary miners safety lamp did not give a very good light. The more modern types give much better light, but even the best of them are not as good as the miner would like. Good light is one of the things most desired by the miner. To have to work in semi-darkness is a great strain on the eyes and greatly adds to the danger of working in the mine.

There is another form of safety lamp which is lit by electricity. Fig. 16. This lamp gives a much better light than the oil safety lamp. It has one bad feature



iner's electric lamp. Fig 16.

and that is the miner cannot test for the presence of firedamp with it. Indeed you never know what kind of air you are in with an electric lamp because it would keep burning even though there was no air at all. However, because it gives a very good light, it is largely used in some countries, especially in the United States of America. The miner uses a gas detector along with the electric safety lamp in order to know the condition of the air he is working in. Sometimes fixed electric lamps, just the same as those you see in trains, houses, and tramcars, are used below ground in a mine. They are fixed in the roof and on the sides of the main roads near the shaft bottom. In this way a very good light is got in places where there is a lot of traffic.

The miner should always take care to keep his lamp clean and bright and well-trimmed. By so doing he will be able to see better to work instead of groping about in semi-darkness. Good lighting greatly adds to the safety of the mine. The better the light the miner has, the more readily will he be able to see danger and to avoid it.

CHAPTER VII.

VENTILATING THE MINE.

To ventilate a mine, simply means to keep the air in the mine fresh and perfectly fit for breathing. You all know that even a house requires to be ventilated. If you were to close the doors, windows and every little hole through which air could come how long do you think you could live in the house? As you breathe, you use up the oxygen in the air and breathe out another gas which cannot be breathed over again. Just let us imagine that a boy is confined in an house into which no fresh air can enter. He would be quite comfortable perhaps for some time, but slowly the oxygen would be used up. After a time he would begin to breathe more quickly, then panting would set in. One can hardly bear to think of what would follow. Gasping for breath, the boy would grope round the room trying in desperation to make a hole through which the life-giving air could come. Imagine him shut up in that air-tight room, gasping open-mouthed and clutching at his throat as if to tear away the unseen hands that were slowly strangling him. To him, at that moment, no blessing on earth could compare with a breath of fresh air. The thing which through the great bounty of nature is free and unstinted to all of us would be of more value to him than all the jewels of India. We will not think that that poor boy lost his life. Rather let us imagine that some kind

rescuer appeared on the scene, knocked down the doors or the walls and let the glorious free air of heaven blow in on him in time to save his life. What joy would be his and what a happy ending to what would otherwise very soon have been a tragedy.

Now the moral of this imaginary story is that no one can live without fresh air, and the purer the air, the healthier are the people who breathe it. The miner must therefore be supplied with fresh air. If the workings are not far from the surface and there are a lot of openings it is quite easy to ventilate the mine. The wind simply blows down some of the openings and the bad air from the mine comes up the others.

Even where the mine is connected to the surface by vertical shafts as described in Chapter 5 it may sometimes ventilate itself in this simple way. The fresh air flows down one shaft, passes through the workings and escapes up the other shaft. But this simple method is not good enough if the mine is a large one. Besides there is another reason for ventilating mines over and above providing the miners with fresh air. We have seen in Chapter 6, that in some mines safety lamps have to be used because it is unsafe to use an open light in air containing firedamp. The best way to keep a mine safe from firedamp is to keep a constant stream of air flowing through all the workings of the mine, so as to carry off the gas as it comes off fresh from the coal. If the firedamp is well mixed with air, so that there is at least fifty times as much air as firedamp it is perfectly harmless. To get a steady flow of air a *fan* is used. The mine fan is simply a wheel with paddles like the paddle-wheel of a ferry-boat. The wheel runs in a casing. It draws air in at the centre and throws it off at the edges of the paddles. The centre of the fan is joined to the mine shaft so that

air is drawn out of the mine, while air flows down the other shaft to take its place. Fig. 17 shows a picture of how the air flows into and out of the mine.

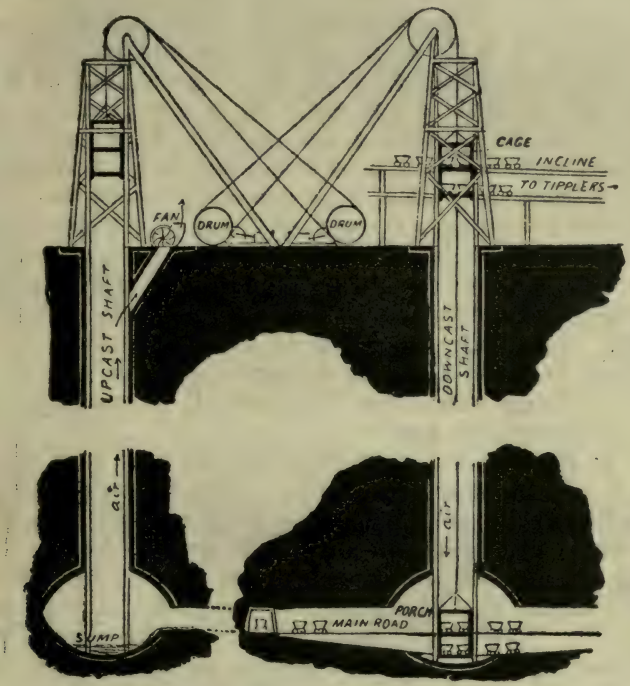


Diagram showing cages, ropes, headgears, winding engines and fan for ventilating the mine. Fig. 17.

It is not sufficient to cause the air to flow into the mine. As it passes through the workings it must be guided into the places where the miners are at work, for it is there that the fresh air is needed. It would not do to let the air flow anywhere it liked. To make it take the proper road, air-tight doors, or

brick walls, or sometimes simply doors of canvas cloth are placed on the galleries along which the air should not pass. In this way it is caused to pass into all the working places so that all bad gases may be swept out of the mine and the miners have pure air to breathe. Besides firedamp, there are other bad gases found in the mine. *Black-damp* is one of those. It is so called because if there is a great deal of it in the air, a light is put out. It is given off by the coal and by breathing and lights. It is not very deadly but care has to be taken not to go into places where there is a lot of it as one might easily be overpowered because of the air not being fit for breathing. Another gas which is much more dangerous is *white-damp*. This gas does not put out a light and it is very difficult to detect. Luckily white-damp is only met with near underground fires and after explosions. When you are learning science you may see these gases being made, for they can all be made in the science room of a school.

In deep mines in England the air gets very warm as it passes through the mine. You know, of course, that the rocks get warmer the deeper we go into the bowels of the earth. In your geography lesson you will learn that volcanoes throw out molten rock. This shows that the inside of the earth is very hot indeed. The heat comes off from the rocks and warms up the air as it passes along. Warm air, especially if it is moist as well, is not very nice to breathe or to work in. In order to keep such mines cool, very large currents of air are caused to flow through the workings.

It is not quite the same in Indian mines. For one thing the mines here are not so deep as in England. Then again the air in India for a large part of the year is already very hot at the surface, whereas in England it is much cooler.

The air in passing through a mine in India, therefore, does not get warmer but cooler, quite the opposite from what happens in an English mine. This is because the air at the surface is already hotter than the rocks even in the deepest part of the mine. Now you will learn in School when you study Science that heat always travels from the hotter to the cooler body. Thus if the air passing through the mine is warmer than the coal, heat will pass out of the air into the coal, with the result that the air becomes cooler.

It happens often that air enters a mine on a hot day say at 100 degrees Fah, and leaves it at 70 degrees Fah, having cooled to the extent of 30 degrees in its passage through the mine.

You can see then that the miner may work in greater comfort than people on the surface, for as you all know, it is more pleasant to work where it is cool than where it is hot.

Everything depends on the ventilation however. If there is plenty of air blowing through the mine it will be cool and pleasant to work in, but if the ventilation is poor, the air will be hot and stuffy and laden with smoke.

The miner himself can do quite a lot to help the officials of the mine to keep the ventilation good. If he passes through a door and leaves it open he may upset the ventilation of the whole mine. Therefore when he opens any door he should always see that he shuts it properly again. He should note the way the air is blowing. This he can easily do by throwing a handful of dust into the air and watching how it travels or by noting in what direction his lamp flame is blown by the air. If he sees signs of any gas in any working place he should leave that place, warn all others to do the same, and inform one of the officials of the mine at once.

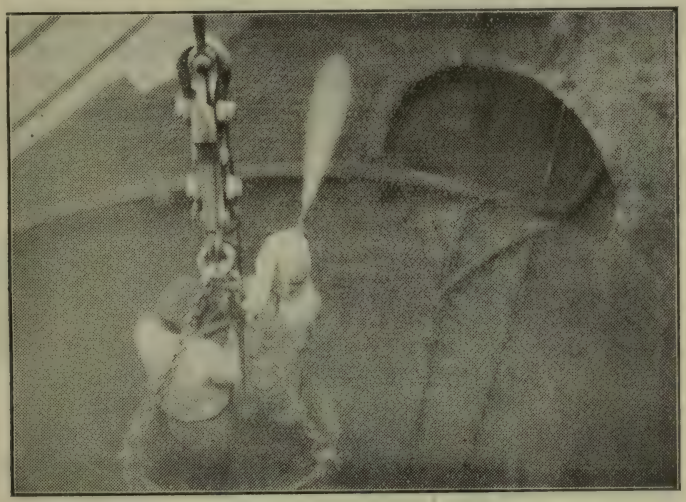
CHAPTER VIII.

KEEPING THE MINE DRY.

A mine is a hole in the ground and as you know very well a hole in the ground is soon filled with water during a heavy shower. During the rainy season a great deal of water gets into the coal mines. The way the ground is broken up, due to the collapsing of the roof, which we described in chapter 4 makes it very easy for water to get into the mine. In some cases the water simply pours through the cracks in the rocks. In such cases it is often not easy to get the water out again because there is so much of it. Besides during the wet season much of the water runs back into the mine again. The water is raised out of the mine but it has to be poured on the surface somewhere and you can easily see that most of it will be sure to run down into the mine again through the cracks in the rocks.

There are several ways of raising the water out of the mine. For instance in a shaft which is being sunk the water is raised in large steel pails or buckets. The water collects in the bottom of the shaft, which of course is simply a deep well. The bucket is hung from a rope and lowered down to the bottom. If there is a lot of water the bucket may fill itself, if there is only a small quantity of water the sinkers ladle the water into the bucket by means of smaller vessels. In this way the shaft bottom is cleared of water so as to enable the sinkers to work.

Fig. 18, shows a sinking bucket with two sinkers in it. They are spraying the sides of the shaft with liquid cement. One part of the shaft is kept a little deeper than the rest so that the water collects there while the rest of the shaft-bottom is dry. Sometimes, if there is much water running into the shaft from the surrounding rocks, a *pump* is used for raising the water instead of a bucket. The pump is fixed or hung in the shaft.



Miners in a sinking bucket spraying the sides of the shaft with liquid cement. Fig 18.

The water is sucked up to the pump through pipes, the pump being placed some distance above the water level. The distance from the pump to the bottom of the water must not be more than about 30 feet, and it is usually less than this so that the pump may draw its water easily. From the pump the water is forced upwards to the surface through a column of pipes. There is hardly any limit to the height the

pump can throw the water. If the pump and the engine driving it are strong enough, the water may be raised to almost any height. The pump may be worked by hand, just like an ordinary well pump, if there is not much water to be pumped and the shaft is not deep. But usually a pump is worked by an engine or an electric motor. Some pumps have a ram or piston which moves to and fro in a chamber and forces the water up the pipes. Another kind consists of a wheel which draws in the water at its centre and whirls it off at the edge of the wheel, whence it passes into the pipe and so up the shaft.

Pumps are also placed in the underground workings of the mine. The pump is usually placed at the lowest working part of the mine, or any other place where water collects. In some mines there may be quite a number of pumps working. Some of these pumps deal with large quantities of water.

In the rainy season the quantity of water flowing into many coal mines is very large and the pumps have to be kept hard at work all the time. If the pumps should break down and stop or if the amount of water coming into the mine is more than the pumps can deal with, there may be great risk of the mine being "drowned," that is, filled with water. This would stop the miners from working and put the company owning the mine to great expense and trouble to get the water out again.

Dealing with the water forms not the least of the many troubles which face the manager of a coal mine. If the amount of water to be "pumped" out of the mine were nearly the same all the year round, as it is in many of the mines in England, the mine manager would easily know how many pumps to put in the mine. But in a country where it rains heavily for a few months and then hardly rains at all for the rest of the year it is not an easy matter to

deal with the water. The pumps may hardly be needed at all in the dry months of the year and in the monsoon they may be quite unable to deal with all the water. The only way for the mine manager to be perfectly sure that his mine will not be flooded out is for him to have enough pumps in the mine to deal with the water during the monsoon. Most of the pumps will be idle during the dry weather but that cannot be helped. During the monsoon most mines raise far more water than coal and the water pumped out of the coal mines of India if all run into a single stream would form a river as big as the Ganges.

The risk of large quantities of water getting into the mine suddenly may be a source of great danger. For example, if coal is being worked under a large river care must be taken so as not to allow the roof to collapse to such an extent as would let in the river. You can imagine what would happen if coal was being taken out not far below a river and the ground suddenly fell in. The river would pour into the mine and flood it out in a very short time. Afterwards there might be little or no chance of pumping it dry again. On one occasion a bad accident was caused through water breaking into a mine. It was not due to a river breaking in, but the quantity of water was so great as to be almost equal to a river.

At one part of the mine the pillars of coal had been taken out and the ground had collapsed. If the coal is near the surface this always causes large holes in the ground and big cracks down which water can pass very easily. On the further side of the broken ground there was a great stretch of low-lying ground so that any large quantity of water collecting there would very soon flow towards the broken area and get into the mine. A high bank, was made between the low-lying ground and the broken area to protect the latter from a possible in rush of water.

This bank held back the water during the rains of 1917, but after very heavy rains in 1918 it gave way suddenly, and the water rushed over the area of broken ground. It thus streamed through the cracks and holes in the rocks into the mine. There were 155 persons at work in the mine at the time. Luckily most of them got out of the mine in time, but three poor persons, two women and a child, were drowned. A sad feature about this incident is that if those three people had but fled uphill instead of downhill their lives would have been saved. Five women working in the next gallery escaped with their lives by going in the right direction.

When a mine is abandoned—that is, work in it is stopped for a long time,—the mine fills up with water. In order to protect each mine from the neighbouring mines a barrier of solid coal is left all around. This barrier prevents the water in the abandoned mine from breaking into and flooding the other mines. On one occasion however a barrier between an abandoned mine full of water and a working mine gave way. There were only 7 men, in the mine at the time. Four escaped but three were cut off and drowned. When a mine is "flooded" the pumps are of course "drowned" as well, and if the mine is to be pumped dry again other pumps have to be obtained.

Sometimes the miner may be working on coal which is not far from old workings full of water. In such a case as this he has to be very careful. The *surveyor* of the mine may be able to tell how thick the coal is, but sometimes even he is not quite sure. A bore-hole should be put through the coal to find out its thickness and to see if the old workings are really full of water. In this way the miner knows exactly how far he can cut the coal with safety.

CHAPTER IX.

AN EXPLOSION IN A MINE.

In chapter 6 we learned that it is necessary in some mines to use safety lamps. This is because of a very explosive gas called firedamp. Where this gas collects in a mine it is not always possible to prevent it catching fire. Firedamp is not nearly so common in Indian mines as in English or American mines. All the same, now and then an explosion takes place in Indian coal mines. Not long ago an explosion occurred in a shaft which was being sunk. A round of shots had been got ready at the bottom of the shaft. The shots were to be fired by electricity. The sinkers ascended the shaft to the surface. When all was ready, the charges were "fired." Immediately a terrific explosion took place. The force of the explosion was so great that the pit-head gear built of strong steel girders was blown down and the girders badly twisted. The shots had set fire to firedamp which either had been in the shaft before or released from the rocks by the shots.

Another accident of this kind took place in a mine in the Bengal Coal Field. The Chief Inspector of Mines in India in his report on this accident said that it "must be classed as one of the most extraordinary in the history of the coal mining." In the mine firedamp was given off from the seam continually. For some time, by using a fan to blow air into the mine it was possible to clear the gas away quickly enough

to prevent an accident. Sometimes so much gas would come off from the coal that the miners had to beat a hasty retreat and escape up the shaft. At last, inspite of the fan, there was so much gas in the air that it was unsafe for the miners to work. Then orders were issued that no one was to be allowed to go down the shaft until the gas was cleared away. Slowly but surely the gas overpowered the fan until the shaft was filled to the top with a highly explosive mixture of gas and air.

One day during a thunderstorm a loud report was heard, a violent explosion had taken place in the shaft and had wrecked the pit top. It was afterwards found that the gas in the shaft had been exploded by lightning passing down the winding rope to the side of the shaft, thereby causing a flash.

Explosions have also taken place in the underground workings. In one case fourteen lives were lost, and in another twenty-seven.

Even this explosion however was a small affair compared with some which have occurred in other countries. Some years ago in France an explosion took place which wrecked three mines and killed over a thousand miners. What a disaster? It makes one shudder to think of it. The explosion started at a certain point in one of the mines and the death-dealing flame rushed through every hole and corner of the workings. In a few minutes what had been a busy hive of workers was turned into a vast ghastly charnel-house of the dead and the dying.

We should explain however that a disaster of such size as this can hardly ever be due to fire-damp alone. In chapter 7 we have seen that if a good flow of air passes through the mines the explosive gas is swept away as fast as it is produced. If it is'nt, then the safety-lamp should show it and the miners would be withdrawn till the gas had been cleared

away. If the ventilation is good, gas can only gather in those places through which the current of air does not pass. Therefore if an explosion takes place it cannot spread throughout the whole mine. For this reason an explosion of firedamp is nearly always confined to a few places in the mine.

In many mines, however, large quantities of dry coal-dust are found. Now coal-dust is also highly explosive ; just as much so as firedamp. It has been proved that coal-dust will cause an explosion even though there isn't any firedamp in the air. Now coal-dust is found every where in a mine ; in all the galleries and in all the working places. It is easy to keep the mine fairly free from firedamp by sending plenty of air through the mine but it is not so easy to clear out the coal-dust. It is of course only the fine coal-dust that will cause an explosion, that is dust which can float in the air or be easily raised into the air by sudden shock. It was coal-dust that made the big explosion of which we have just been speaking, and all the large explosions, in England, America and other places have been wholly or partly due to coal-dust. One thing that must be done to reduce this danger is to keep the main roads and working places as free from coal-dust as possible.

If the coal-dust is well drenched with water it is harmless and this is often done. Another way to make the coal-dust harmless is to cover the roads with fine stone dust, The stone-dust makes it difficult for the coal-dust to catch fire just as a fire in your house in which you had more stones than coal would be difficult to keep in.

Clever men have been at work and are still busy, on the problem of explosions in mines. Their task is a difficult one but great progress has been made. Big mining explosions are getting less common, in spite

of the fact that mines are getting larger and deeper and therefore more difficult to work.

Luckily the coal-dust danger has not shown its face—if we may speak thus—to any great extent as yet in Indian mines. There have been a few small coal-dust explosions, however, sufficient to show that we have got to be on our guard against the danger. As our Indian mines grow larger and we have to go deeper down for the coal no one can say whether our difficulties may not increase. It may be that measures may yet have to be taken to safeguard the miner against the coal-dust danger. If that ever comes you may be quite sure that our mining men will be quite fit for the task. Science, in time, can overcome almost any danger with which the miner is faced.

Before we leave this subject let us talk about the condition of the mine after an explosion, and see also what the miner does to rescue his comrades who may have been in the mine when the explosion took place.

When an explosion dies down, the mine is full of a gas which is a deadly poison. This gas is called *After-damp* because it is found *after* an explosion. Afterdamp is really a mixture of gases. The flame of the explosion uses up the air and leaves other gases behind. Afterdamp is usually made up of black-damp, white-damp and some unburnt air. It is the white-damp which is so deadly. It is said that only one in every four of the victims of an explosion are actually killed by the force or flame of the explosion. The remainder are suffocated by the after-damp. You can see then that the chance of rescuing any of the miners after an explosion is not very good. Nevertheless the men who are in safety on the surface are always ready at once to go into the mine to save their fellows if that be possible. To go into a mine after a large explosion simply as

one stands however would be to go to almost certain death. Instead of being able to rescue anyone, more deaths might be caused.

But the miner may go into the deadliest gas in safety. He is provided with a special dress called a "rescue-apparatus." Fig. 19. This dress carries a supply of air fit for breathing and the wearer is shut off completely from the surrounding poisonous gases. The rescue-man breathes from his apparatus through a mask which covers his mouth and nose so that the poisonous gas cannot get to him. Thus prepared the miner can now go into the mine and attempt the rescue of his unfortunate comrades. The miners form themselves into a rescue-party. There are generally five or six persons in the party. They are all men who have been trained in the use of the rescue dress, for the dress itself is a danger unless the wearer has been taught how to use it. One of the members of the party is called the "Captain" and acts as the leader. Each member wears a rescue dress and each carries an electric safety lamp. One of the party carries a small cage containing a canary. The canary is for the purpose of testing the air in the mine. A canary is more easily poisoned by white-damp than a man. By watching how the canary behaves the rescue-man knows whether or not the air contains white-damp. If the bird becomes dazed or falls down unconscious it is high time for the men to beat a retreat. Two of the party carry a stretcher so that if they come on any one in the mine, they can readily carry him to a place of safety.

The rescue party works for two hours only, for their supply of air does not last any longer. Then another rescue party takes the place of the first and so the work goes on. The miner is very brave and will gladly run the risk of his own life if there is the slightest chance of saving one of his comrades. Alas !



A miner wearing rescue apparatus. Fig. 19.

it is not often that there is any one left to save after a big explosion. The dreadful after-damp does not take long to do its deadly work. But while there is a chance we must keep on trying to save the lives of those who risk so much in the mine.

Firstly every posible precaution must be taken to prevent explosions, and secondly, we must be ready, if an explosion should occur to do our utmost to save life.

CHAPTER X.

A MINE ON FIRE.

A mine on fire! What a blaze it must be! Some of you may be living on the coal-fields and may have seen a mine on fire. Most of you however will not have seen such a thing. You can well imagine, though, what it would be like for the coal seam, say on the face of a large quarry, to catch fire. If it were not checked and put out at the very start it would soon spread over the whole face of the coal, making a huge bonfire, as it were. There is just such a fire raging in the Jharia coalfield at the moment these words are being written. The coal was known to be on fire not far from the quarry workings but it was shut off by brick stoppings in the galleries. Unnoticed the fire had been slowly creeping up towards the quarry. One night a fall of roof took place which allowed the fire to rush forth, as it were, like a lion that had been caged. In a very short time the fire had caught on to the pillars of coal in the quarry and in a few hours the whole of the face of the quarry was a mass of flames and smoke. There are several ways in which the coal may be set on fire. It might be done by some one setting fire to timber either by accident or from mischief. Or again a fire might be started through a firedamp explosion. If firedamp gathers in an empty space and there is not much air mixed with it, it may go on burning for quite a long time after it is first set on fire.

The flame and heat of the burning firedamp if in contact with coal or timber may not be long in setting the coal itself ablaze. One incident of this kind happened in a mine known to the writer. An advance gallery was being driven towards old workings from which nearly all the coal had been removed. The old workings, it was supposed, might contain firedamp. The thickness of coal between the face of the gallery and the old workings was known to be small. The miners were therefore told to work with safety lamps until a hole had been driven through the strip of coal. One of the miners however disobeyed orders. He said afterwards that he could not see to work with the safety lamp and for this reason used his open light. About half-way through the day's work the miner knocked a hole through the coal and at once there was a rush of air from the old workings. The air contained firedamp and almost immediately a loud explosion took place. The gas had been set on fire by the open light. The miner was severely burned and had a narrow escape from losing his life. The other miners at work were some distance off and so escaped injury, for the explosion did not extend forward into the new workings. The gas continued to burn in the old workings for a long time. It set fire first to the timber of which there was a great deal and then to the coal. In a short time the fire was a raging furnace. For over three weeks, men worked hard to put out the fire. At last by pouring water on it and by digging out the hot and burning coal the fire was conquered.

Another fire in the writer's experience was caused through a bad electric cable. Have you heard of electricity? It is a wonderful power which flows along wires and drives all kinds of machinery as well as giving light. Well this accident happened at a lamp cabin in the mine. There were electric lights

in the cabin. The wires carrying the electric current to the lamps were covered with rubber and jute. The purpose of this covering is to keep the electricity in the wire, just as pipes keep water from getting out. If there is a hole in the pipe some of the water will get out. It is almost the same with electricity. If the covering is torn away and the wire touches iron or other metal or even coal, some of the electricity will flow out of the wire at the damaged place. When this sort of thing happens there is a great risk of an accident if the defect is not found and put right. A hot spark or flash may take place where the electric current leaves the wire and if there is anything near that catches fire readily you can easily imagine what would happen. Well, in the case we are writing about, the roof of the lamp cabin was held up by timber which was very dry. The fire started when nobody was near and soon a vast cloud of dense smoke was being carried into the workings by the air current. Dense smoke in the narrow galleries of the mine is a very deadly thing. A human being cannot live in it for long. There were a number of miners at work in the mine at the time, and most of those lost their lives through suffocation by the smoke.

Fires have occurred in mines simply through carelessness on the part of miners. For instance a fire took place once through a miner carelessly allowing his lamp to come into contact with a canvas screen hanging in an "airway." The screen was very dry and much frayed at the edges. As the miner passed through the screen his lamp set fire to the frayed edges of the screen. He was in a hurry and did not notice what his lamp had done. In a few minutes the screen was ablaze. It set fire to the timber forming an "aircrossing" overhead. An "air-crossing" is formed by one airway passing over another.

Luckily the fire was noticed and quickly put out or no one knows what tragic event might have resulted for there were a great many miners at work in the mine at the time. Still another fire was caused in an Indian mine through a miner hanging his lamp on a prop and leaving it there. The prop caught fire and then afterwards the coal, and a blaze was started which burned for years.

Most big underground fires however start themselves. Now this is sure to set you wondering. How can a fire in a mine start itself? On the surface we often hear of dry grass and wood catching fire from the hot rays of the sun; but the sun's rays cannot get into a mine. How then can coal catch fire unless some one sets it alight? It is not easy to explain this in simple language but we shall try to tell you something of what happens. Suppose you have a heap of small bits of coal mixed perhaps with dirt particles. It does not matter much whether the heap is on the surface or underground, but we will suppose that it is in the mine. Now a piece of coal even though just lying on the ground is slowly but surely "burning" away. Suppose you were to leave a piece of coal on the ground for a long time where no one could touch it. At the end of the period the coal would not be the same as it was at the beginning. Some of it would have disappeared just as if it had been burning very slowly, so slowly that no change could be seen from day to day by the naked eye. But for all that it would be "burning" just as surely as if it were in a fire. Of course this behaviour is not called burning, but "oxidation," and we are trying to explain it in a simple way as "burning very slowly." Another thing you need to know is that this slow burning produces heat just as if an actual fire were taking place. The heat is small of course compared with a fire. In the heap of coal under-

ground this slow "burning" goes on, not only on the outside but in the inside of the heap as well. The air gets into the inside of the heap through the very small spaces between the bits of coal and stone. Now the heat caused by the slow burning in the inside of the heap cannot get out easily. Suppose on a hot day in June you put a thick blanket around you. Would you be cool or hot? Hot of course. Why? Well simply because you were keeping in the heat of your body instead of letting the breeze from the punkha keep you cool. It is the same with the heap of coal. The outer parts of the heap keep in the heat of the inner parts just like a blanket. And so the inside of the heap gets hotter and hotter until at last it gets so hot that it breaks out into an actual fire. Rather wonderful isn't it? The same sort of thing might take place in a crack in the coal which contained coal-dust. The coal-dust would heat up, burst into flame and set fire to the coal. This has been known to occur in an Indian mine in a crack right in the centre of a pillar.

When a fire of this kind is discovered the miner attacks it at once. First he may try to "drown" it out by water if he has plenty of water near at hand. Or he may try to dig it out, filling the hot coal into trucks and taking it to the surface. Or he may throw clay balls at it; or again he may use *fire extinguishers* such as are often used to put out fires in houses. Sometimes he may use all these methods one after the other or altogether. If the fire has only just started he may succeed in putting it out.

But if the fire has got a good hold he may find that it cannot be put out easily. He then decides to cut off the fire from the rest of the workings. Brick walls called "stoppings" are built in all the galleries leading to the fire. In this way the fire is prevented from getting air. If this is done properly

the fire may slowly die out, for air is just as necessary to a fire as to human beings.

It is often a very difficult task however to put out a mine fire because it may draw air through cracks in the coal or rock in spite of the stoppings. Crores of tons of coal have been lost in India through mine fires and although the miner tries his best to prevent them and to put them out when they do take place, the problem is not an easy one to solve.

CHAPTER XI.

INSPECTING THE MINE.

The mine owner is not allowed to work his mine in any way he pleases. He must do certain things to protect his workmen from risk of injury. The Government of India have passed Rules which state what measures must be taken to prevent accidents. The mines must be worked in agreement with those *rules*. Special officers who are experts in mining are appointed by Government to inspect the mines and to see that the Rules are put into force. These officers are called Inspectors of Mines and the head officer is the Chief Inspector of Mines in India. They carry out their duties in the following way. An inspector visits a mine and inspects the surface works and the underground workings. He sees if dangerous machinery is guarded, and if the working parts are in a safe condition ; examines ropes and chains etc., notes whether abandoned roads and workings are probably fenced off ; taps the roof and sides of pillars to see if there is any loose coal hanging about ; and in short examines all parts of the mine to see if it is being worked in a safe manner and in agreement with the Indian Coal Mines Act and Rules. The inspector then reports on the state of the mine. Most mine managers take great care to see that the mines in their charge are worked in a safe manner. There are a few however who are not quite so careful. They may allow miners to work in dangerous positions.

If it is found that a mine has been worked in an unsafe condition, the officials of the mine may be taken to court and charged with an offence against the Coal Mines Act. There are a number of persons fined every year for offences against the Act.

The chief official at a coal mine is the *manager* of the mine. The larger coal companies employ *agents* who have a group of mines and several managers under their control. The agent has generally served previously as a manager. The manager has charge of the mine as a whole and has to see that all those under him do their duty. One manager may have several mines under his charge, for many of the mines are quite small, that is, only a few miners work in them. The manager of a mine must be very well educated. He must know a lot about science and engineering, besides his own subject of mining. He has to pass a stiff examination before he gets the certificate which permits him to manage a coal mine. The examination for manager's certificates is held once every year at Dhanbad, on the East Indian Railway, the head quarters of the Chief Inspector of Mines in India. Many people try to get this certificate but only a few are successful. There are schools on the coal-fields and elsewhere in India in which training is given to students who wish to prepare themselves for the coal mine manager's certificate. It takes much study to be able to pass the examination.

There are two classes of certificates, a first and a second class. The examination for the first class certificate is more difficult than that for the second class certificate.

You see, the Government of India does not allow anyone to manage a coal mine. If anyone who wished to do so could take charge of a colliery the number of accidents in mines would be very much greater

than what it is. Besides it would be very bad for the mine-owner if any Tom, Dick, or Harry were allowed to manage a mine. A mine which is cautiously and safely managed is, in the long run, the best paying mine. In a coal mine it always pays to put safety first. If a man who knows very little about mining were put on to manage a large colliery he would not only be a source of danger to everyone in the mine but very likely he would sooner or later bring the mine itself to ruin through his own lack of knowledge.

Sometimes if the mine is a small one, a permit may be granted to a person, who does not possess the Government certificate, to manage the mine. But in such a case as this the Inspector of Mines always holds a personal examination, in which, by asking questions on mining, he finds out if the man desiring to be granted the permit knows enough about mining to be trusted to work the mine in a safe manner.

The other officials of the mine do not require certificates but they require to be fit for their duties and to have been appointed in writing by the manager of the mine. The *overman* is the highest official without a certificate. The overman's duties are chiefly below ground. The *sirdar* has charge of a district. A district consists of a number of working places forming a group. The overman or the sirdar has to examine, at least once every day, every part of his district in or through which any person has to work or pass. If no one has been at work during the previous 24 hours, the examination must be made not more than two hours before anyone is allowed to enter the district. He must examine the roof and sides and see they are safe, and if not, give orders that they be made safe. He has to see that there is plenty of timber set in order that the miner may work in

safety. He examines the ropes, chains, signals, fences, stoppings, doors, air crossings, etc. If there is a possibility of firedamp being in the air he tests for the gas with his safety lamp. First he lowers the flame of his lamp, then raises the lamp slowly from floor to roof. He watches the flame very closely to see if there is any sign of a "gas" cap. If he finds gas present he stops any one at work in that place and reports to the manager. The gas is then removed before anyone is allowed to go near. Besides all this he has many other duties. Indeed his whole time is spent in seeing that the "safety first" rules are carried out. The miner is not always too careful of his own or his neighbours safety. Very many of the accidents that happen in the mines are due to the carelessness or ignorance of the miner himself; and much of the time of the under-officials of a colliery is devoted to protecting the miner, so to speak, against himself. Another important official at the mine is the surveyor, who makes the plans of the mine, showing how it is placed with regard to the neighbouring collieries.

You may have got the impression as you read through this little book that the mine is a very dangerous place in which to work. As a matter of fact such is not the case. There is far more danger on the surface from snakes, and cholera, and malaria, than there is in the coal mine. For every person who loses his life in a coal mine, many hundreds are killed by snake bite. And there is more danger from motor cars in the busy streets of Calcutta, Bombay, or Madras than in the dark passages of the mine. Much is being done, too, to lessen the dangers of the mine. Although work in the mine can never be altogether free from danger it may be made safer and safer as time goes on. One of the means

of making it safer is to educate the miner in the dangers of his calling and how to avoid those dangers. The miner should know the *rules* made for his safety, and should always carry out those rules and see that his fellow-workers do the same.

CHAPTER XII.

A MODERN COLLIERY.

Many of the collieries on India are worked in a very simple manner. In some there is no machinery at all; in others the only machinery is a small steam boiler, a steam pump for raising the water and a winding or hauling engine for raising the coal. There are many mines however which use machinery on a large scale and the number of these is increasing every year. A colliery which uses machinery to the fullest possible extent we call a modern colliery. We are now going to see what such a mine is like and how it is worked; and as you read the story of it, you should keep in mind, that you can see everything that is mentioned at quite a number of the coal mines of India. Let us imagine that we are visiting a modern Indian colliery a photograph of which is shown in Fig. 1, frontispiece. First of all we shall inspect the surface works. Let us look at the great boilers for raising steam. They are tube-like steel vessels set in brickwork. Two smaller tubes pass through the centre of each boiler. The front part of each of these smaller tubes forms the boiler furnace. See, a fireman opens the door of one of the furnaces. A blazing mass of burning coal is seen. After "cleaning" the fire by raking out ashes and "clinker" the fireman shovels on fresh coal to feed the fire. Then he closes the furnace door and proceeds to do the same with

the other furnace. Steam hisses and spits all round us. Close to the furnaces the heat is intense and we do not envy the men who do this work.

The boiler is more than half full of water and the steam collects in the space above the water. The steam is at a great pressure inside the boiler. A pressure-gauge with a face like a clock or watch gives the pressure of the steam. The fireman must see that the pressure of steam is kept up. See! the pointer stands at 100. This means that the force of the steam is equal to a weight of 100 pounds on a space of one square inch, or about 6½ tons on a space of one square foot. That is, there is a force of 6½ tons on every square foot of the boiler trying to burst it open. No wonder, you say, that boilers burst sometimes. Of course the boiler is built to stand this force. Indeed if the boiler is really safe it ought to stand at last five times the force of the steam when working. But boilers, like everything else, get weak with use, and they have to be examined often to see if they are still safe. The force of the steam in the boiler is prevented from becoming greater than what is allowed by a safety valve through which the excess steam escapes. The water is forced into the boiler by a pump. The steam passes through a pipe to the engines. There are no less than eight of these boilers. Close-by, there are another two boilers of a different kind.

We will now look into the power-station. The manager of the mine, who is showing us the "sights," explains that he uses electricity in one of his mines and compressed air in another. The engine house we go into now is where the electricity is made. We have mentioned electricity before. The engines driving the electric machines are rotary engines, that is, they do not go to and fro like an ordinary steam engine but round and round at a great speed. They

are joined to the electric "dynamos" which go round with the engines. The dynamos seem to be built of wires more than anything else. Over at the side on a raised platform is a great board covered with lights, clock-faced electricity meters, and many other things. Everything is perfectly clean and brightly polished. Here it is quite nice to stay. There is not too much noise, the hum of the engines is quite bearable. The manager explains that the electricity is sent from here to several mines round about. He points through one of the windows to a long line of wires carried on steel trestles. The trestles are laced round and round with barbed wire. The barbed wire is to prevent wilful people climbing up and perhaps coming into contact with the wires. Not long ago a poor girl was killed through climbing one of these poles and touching the electric wires. She saw a bird's nest up there in the wires. Slowly and painfully she climbed up over the barbed wire. When near the top she took hold of the electric wires to steady herself and was killed. Of course she knew nothing about the great danger there is in electricity. Let us take this warning to heart and always be on our guard not to trespass where it is clearly intended that we should not go. This poor girl ought to have known that the barbed wire was put there to prevent people climbing, and that the reason must be that it was dangerous to do so.

In the electricity house wherever possible the dangerous parts are well-protected or notices put up that it is dangerous to touch. Where electricity is concerned it is wise never to touch anything unless you are told by someone who really knows that it is safe to do so. We pass next to the winding engine. We have mentioned a winding engine before (in Chapter 5). This one is much the same. It is driven by steam. The manager says that the winding

machine at one of his other pits is driven by an electric motor.

Next we are taken to the fan-house. The fan is driven by an electric motor. The fan itself is not to be seen. It is all closed in. We go through two side doors, and into the fan-drift. Now we see the great fan whirling in its casing. The air is blowing like a hurricane all round us. This fan "draws" about 4 tons of air out of the mine every minute, or over 8000 tons of air in 24 hours. The mine raises only about 600 tons of coal a day. So you see that about 13 tons of air have to be passed through the mine for every ton of coal raised. Perhaps you never thought that air has weight, just like sugar, or rice, or coal. Of course air is very light. It takes about 28,000 cubic feet to weigh a ton. But then the fan draws well over 100,000 cubic feet of air every minute through the mine. Luckily nature has provided an unending abundance of air, and no matter how much bad gas is given off in the mine, if only a powerful enough fan is used, an ample supply of fresh air can be supplied for hundreds or even thousands of underground workers. We now leave the fan house, and some one says that he would like to see where the compressed air is made. The manager points out, however, that we would be better to "do" the workshops first as they are quite close by, whereas the compressed-air engine is some distance off at another collliery. The workshops are required to keep the machinery of the colliery in constant repair. If an engine breaks down you cannot send it away, say, like a watch, to be repaired. It must be mended on the spot. So workshops must be provided and blacksmiths, carpenters, and mechanics (mistries) employed to do the repair work.

First we enter the blacksmiths' shop. Here three *hearths* are in use. At one special chain

links are being made, at another miner's picks are being sharpened, and at the third a *drawbar* for one of the mine trams is being shaped. In the carpenter's shop, mistries are busy on such things as mending a broken tram, making brake blocks for the winding engine, repairing some of the office furniture. Then there is the machine shop and the foundry where much of the iron and steel work for the colliery is done. There is also an electrical repair shop where broken-down parts of the electrical machinery are attended to. Lastly we are shown the store rooms where all the materials for repair work are kept.

CHAPTER XIII.

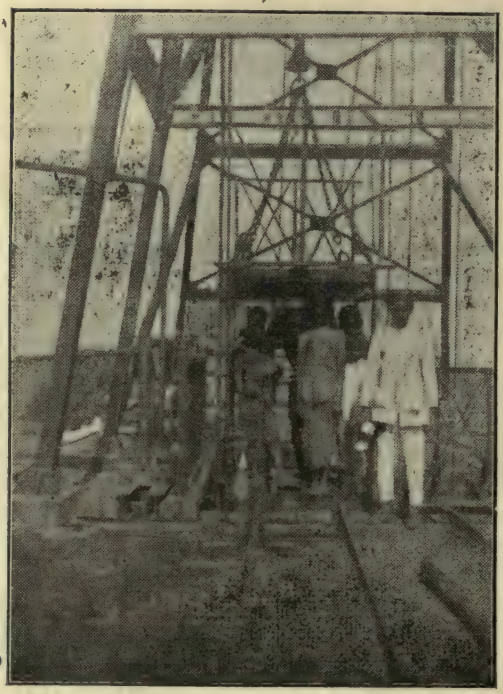
A MODERN COLLIERY (contd).

After a rest in the office, during which the manager very kindly supplies us with cold drinks, we proceed to mine No. 2. It so happens that a train of empty tubs is about to be taken from No. 1 to No. 2 pit. We are told to get into the tubs. When all is ready the tiny locomotive starts off. It puffs and snorts as if it knew it had a rather unusual load behind it. Soon we are rattling along the miniature railway at a great pace. This railway is needed for bringing the coal from No. 2 pit to No. 1 pit where the coal is loaded into wagons. Soon the "train" slows up and comes to rest and we all get out quite excited over our little trip.

The Compressor-house is on our right. The manager explains what the compressor does. He says that it is simply a machine which sucks air from the atmosphere into a cylinder and then squeezes it into smaller space. He calls this *compressing* the air. The compressed air is carried in pipes into the mine and is there used to drive engines. In those engines the air now *expands* and pushes the piston of the engine to and fro. It is easier to understand how compressed air works than how electricity works. One of our party, suddenly struck with what seems to him to be a bright idea, exclaims. "Why! that is surely a very cheap way to get power for you get the air for nothing." The manager smiles and says

"Yes, it is quite true that we get the air for nothing but you forget that the steam engine which drives the compressor uses coal and coal costs money. We get the coal out of our own mine of course but then what we burn in the boiler fires we cannot sell and it must be reckoned as money." The manager tells us further that, far from being cheap to make, compressed air is very costly.

Compressed air costs more than electricity for the same amount of work done, and the manager says that if the compressor had not been there before the electric plant was put down, he would not have had it at all. He means to use the compressor for some time yet but later on he may stop it altogether and use only electricity. Compressed-air is much safer however than electricity. You cannot get a "shock" from it as from electricity and it will not set fire to explosive gas as electricity will. For these reasons some people prefer compressed air even though it is dearer to make. The manager says that there are three chief forms of power used underground in mines in India; steam, compressed air, and electricity. Steam is most used but it is fast giving place to electricity, or where electricity is not safe, compressed air. Steam makes the workings hot and uncomfortable and there is always a great loss of power through steam escaping from the pipes, or turning back to water before the engines are reached. On leaving the compressor-house, the manager says we should now see the machinery in the mine itself. He puts us in the charge of the over-man as he himself has much work on hand at the office. We enter the cage (Fig. 20) which soon rapidly descends. When we reach the shaft-bottom, we observe that it is well lit by electric lamps. This is one of the advantages of having electricity in the mine. The men handling the tubs see to work better so that there are fewer



Miners in a cage at the pit top ready to descend the shaft. Fig. 20.

accidents. There are two long lines of trams laden with coal ready to be sent up the shaft. The full trams are put on the cage at one side while the empty trams are taken off at the other side. A little way from the shaft in a well-lit and cleanly-kept room, a large pump is at work. The under-manager tells us that this pump deals with over 5 tons of water every minute of the 24 hours during the rainy season. There is another exactly similar pump in the room. This pump is not working. It is a standby in case the other goes wrong.

We leave the pump-house and travel along the main road away from the shaft bottom. Soon we reach a haulage plane. In a modern colliery where the working places are a long way from the shaft, the trams are pulled along by ropes. To carry out the coal in baskets or to push out the loaded trains by hand would be painfully slow and costly. In rope haulage the loaded tubs are fixed to the rope by clamps or chains and the rope is pulled on to a drum driven by an engine or electric motor. At the "outbye" end of the haulage plane, that is, the end next the shaft-bottom the loaded trams are unhitched from the rope and empty trams put on. If say, six loaded trams are pulled outbye, six empty trams are sent inbye to take their place.

The "set" is just about to reach the top of the incline as we approach. The overman warns us to stand to one side. When the set has been brought to a standstill we follow the overman down the incline. There are no pillars formed here as yet. The haulage plane is just one long gallery. At intervals there are box-like recesses cut-out of the coal. These, we are told, are refuge holes. The Coal Mines Act requires that these refuge holes must be provided on every haulage plane. If anyone should be on the incline when a set is being pulled up or let down he gets into a refuge hole until the set has reached the top or the bottom as the case may be. Haulage planes are dangerous places to be on when the trams are in motion and these refuge holes form a valuable safeguard against accidents. At many mines these haulage roads come out to the surface. Fig. 21 shows a set of tubs coming out of an incline.

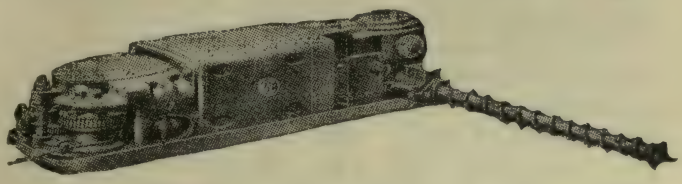
At the foot of the incline we turn along a level gallery. Soon we pass the foot of a *jig-brow*. This is a self-acting incline on which the weight of the full



A set of coal trams being drawn out of an incline. Fig. 21.

tram running downhill pulls the empty-tram up-hill. The two trams are hitched to the ends of a rope which passes round a wheel at the top of the incline. A brake is used to control the speed of the trams. The overman tells us that he is taking us to where the "iron-man" is at work. The "iron-man" is a powerful machine which cuts coal. A little later we hear the sound of the machine at work. As we approach the working place the noise gets louder and louder until when we stand close to the machine the noise is deafening. This machine is driven by compressed-air but electricity is also used for the same purpose. The coal-cutter cuts a narrow slit about five feet deep along the bottom of the coal. The miners afterwards "blow" down the coal with explosives. The machine has now cut right across the place which is about fifteen feet wide. It is

stopped and we examine the sharp picks which cut the coal so easily. The picks are fixed to a steel chain and as the chain is driven the picks tear the coal away. In another kind of machine also used in India, the picks are set in holes on a long steel pole or bar which is made to revolve at a high speed. (Fig. 22)



A coal cutting machine. Fig. 22.

In both machines only a deep narrow slit is cut in the coal but this is all that is needed to enable the miners by means of explosives to blast down large blocks of coal. The driving power of the coal cutter is the air-engine inside the casing. Electric motors are used instead of air engines where electricity is provided. The overman tells us that in No. 1 pit, electric coal-cutters are at work.

An "iron-man" will produce as much coal as a great many miners. There are quite a number of these "iron-men" at work in Indian coal mines and their number is sure to increase greatly in the near future. The "iron-man" will enable the mines of India to produce more coal. It will also make the work of the miner easier. After the "iron-man" has been slowly "backed" out of the working place, it is taken to another gallery where it is set to work.

The miners now start to drill the shot-holes. Even this is done by machinery. Drilling machines like large pistols are used for this purpose. Compressed-

air is also the power used for drilling. The drilling tool is a steel rod sharpened at the end like a chisel. The tool fits into the drilling-machine and the drill-man presses on his machine as it works so as to keep the drill tool hard against the bottom of the shot hole. The machine strikes hundreds of blows a minute and will drill many shot-holes in the time it would take a miner to do one by hand.

The overman next takes us to where "sand-stowing" is going on. Sand-stowing has been mentioned in chapter 4 but this is the first time we have had the chance to see it. We are told that the galleries are being filled with sand and then the coal in the pillars will be taken out. The water and sand flow out of the pipe in a continuous stream. The sand is held back by straw and canvas matting fixed to props, and the water simply drains away to be pumped to the surface again. Our guide explains that sand-packing is the only way of getting out all the coal. He says it prevents the roof collapsing and it is also the best way to prevent the coal taking fire.

On reaching the surface we view the method of dealing with the sand there. The pit is near a large river where there is an immense quantity of sand. The sand is loaded into buckets on the far side of the river and the buckets are carried right across the river on a travelling rope-way. A special shaft is used for the sand-filling. At this shaft the loaded buckets are tipped into a large hopper from which the sand flows into the pipe leading to the underground workings. Water mixes with the sand as it enters the pipe. The manager, who is now with us again, asks if we would like to travel across the river on the ropeway. Gleefully the invitation is accepted. We get into the buckets two at a time and soon we are moving grace-

fully at a height of a hundred feet above the landscape. The other side of the river is reached in safety. Afterwards, when we think over our visit to a modern colliery we cannot help marvelling at the genius of man who seems to have harnessed all the forces of nature to do his bidding.

CHAPTER XIV.

THE MINER AT HOME.

We have seen the miner at work and the mine in which he works. We have seen too the dangers that he meets in his daily toil in the underground workshop and the efforts that are made by all connected with the mines to protect him against those dangers. Let us now pay a visit to a mining village with the mine manager as guide and see the miner in his home and during his leisure moments. You need not think that the miner is greatly harassed by the dangerous nature of his calling. The miner is a great philosopher ; he takes things as they come. He does not worry overmuch about what fate or fortune has in store for him ; he leaves that to the Goddess of Chance, believing, it may be, that what is to be, must and shall be, and that no good will come of his trying to avoid what fate has in store for him. Besides he knows full well that the risk of injury in the mine is very much less than the chance of serious illness when out of the mine. When his day's work is finished therefore the miner spends many a happy hour in his home and amongst his friends. As we go through the village we can see little groups here and there laughing and chatting as if they had not a care in the world.

Many of the large coal companies have done a great deal to improve the lot of the Indian miner. Neat brick houses have taken the place of the old mud huts. It is often difficult however to get the miner to take

kindly to a different kind of house from that to which he has been accustomed and some even yet prefer their own erections to those provided by the coal owners.

The manager points to a group of women and children drawing their supplies of water. The coal company provides all the water required. The drinking water is filtered and purified and is then forced through pipes to taps placed here and there to suit the villagers. The miner does not need to draw his water from a well, all he has to do is to turn on the tap and fill his water vessel or perform his ablutions. In this respect, therefore, the people of a mining village are on a level with those who live in large cities like Calcutta or Bombay. Not only is the supply of water convenient but as the water is pure there is much less risk of disease. Everyone knows that the dread disease of cholera is often due to bad drinking water. Needless to say the villagers appreciate very much this great boon of good drinking water.

Another thing that is being done on the coal-fields is well worth description. In both the Jharia and Ranigunj coal-fields a Mines Board of Health has been formed. The duty of this health board is to look after the health of the people in the mining villages. An expert medical officer is in charge of each district, and they have other doctors under them. They devote much of their attention to inducing the people to be more cleanly in their habits, for everyone knows that cleanliness is one of the best means of keeping healthy. They keep a close watch on any sign of an outbreak of cholera or any of the other dread diseases that sweep over the country from time to time. If a case of cholera is reported the patient is at once removed to the nearest isolation hospital. By doing this not only is the

disease prevented from spreading to other people, but the patient himself has a better chance of recovery, since he gets the closest of attention and the best of medical skill.

Many of the colliery owners, too, employ a doctor of their own. The manager takes us into one of the dhowras. He merely wants to show us the inside of the house. On entering however he hears the moans of some one in distress. At one side of the room on a string bed a woman is lying. The manager asks her what is the matter. She says she feels very ill. The manager takes hold of her wrist and then turning to us he says, "This poor woman is highly fevered, she needs the doctor at once." We come out of the house and the manager calls a chaprasie and sends him for the doctor. A good manager takes great interest in his workers. This one appears to be very well liked indeed for as we go round amongst the villagers, he is greeted with smiles and "salaams" from every side. He knows many of them by name and it is quite clear that they have a real affection for him. A little urchin, practically naked, comes running towards him. Does the manager push him away? No! He pats him on the head and says a few kind words. The little fellow begs "Paisa? Paisa?" The manager smiles and gives the boy a small coin. The child scampers off gleefully to its mother. The manager says that he never comes through the village but the little fellow is after him. He says that quite a lot of "backsheesh" is given on the collieries. It pays sometimes to keep the miners in good humour by paying out "backsheesh" now and then, though of course, it would not do to be too lavish with "money for nothing." He tells us a funny story of what happened to himself once. He was making an inspection of a shaft that was being sunk. The method used was for him to get into a basket and be lowered slowly down the

shaft by a rope. The rope was held by a number of women coolies. He got down all right, made his inspection and was being pulled again. When about half-way up the basket stopped. A face appeared over the mouth of the shaft and a voice shouted "backsheesh." In reply he shouted angrily, "Pull away and no nonsense ;" but the only answer was "Backsheesh, backsheesh." He was inclined to be annoyed, but the humour of the situation overcame his irritation and after promising liberal "backsheesh" he was raised to the surface.

One of the many problems that face the manager of a coal mine is how to keep hold of his small army of miners. Many of the miners work in the fields as well as in the mines. They have little plots of "paddy" fields and in the beginning of the rainy season great numbers of the workers leave the mines to till their rice plots. After the rice has been planted they may return for a short time, but they leave the mine again for the harvest. As a result of this the mine is not always at full working strength. Unless a certain amount of coal is being got out of the mine, it is of course being carried on at a loss. All sorts of inducements are offered to the miners to get them to stay at work in the mine. In some places small rice plots are provided near the miner's houses so that he may to some extent till his fields and carry on his work in the mine at the same time. This cannot be done in every case, however, for very often the ground near a coal mine is not at all suitable for growing rice or anything else.

Some of the coal owners provide games and other amusements for their workers. At least one company has even gone the length of providing their workers from time to time with a free cinema show. Needless to say the miners greatly enjoy entertainments of that description.

Besides being well paid for his work in the mine, the miner gets many things provided to him for nothing. His house and water supply is free. He gets his working tools, lamps, oil and everything necessary for this work free of charge. He gets a load of coal home with him whenever he likes. He gets the services of a doctor and medicine when he needs it. He gets frequent "backsheesh." He has perfect freedom to go into the mine when he pleases and to leave off work when it suits him. He can transfer his services from one mine to another as he pleases, and he often does this not from any good reason but from mere caprice.

Altogether the miner is very well off compared with many others workers in India. You must not be led to believe of course that the miner's life is a paradise. It is very far from that. We have seen a little of the kind of work he has to do and the place he works in. We see that the work is hard, uncomfortable and dangerous. For such work he is not overpaid, even when the many things he gets free are considered. His conditions of life in the mining villages are not, by any means, all that could be desired, and there is yet much to do to improve matters. That the miner deserves good living conditions you will all agree. The coal owners are quite alive to the need for improvements and many of them are, without doubt trying their best to make living on the coal fields more pleasant and attractive. A type of miner who will work in the mine with reasonable regularity is what the coal owner desires. He knows he cannot get this unless he makes the miner happy and contented. Much depends upon the miner himself however. He is difficult to wean from his old ways and he does not take kindly to new ideas and methods. All the same, as you can see

from what we have said in this chapter progress is being made, slowly but surely, and, even as things stand, life on the coal-fields compares quite favourably with conditions elsewhere.

CHAPTER XV.

MAKING COKE.

Many of you have seen a piece of coke ; perhaps some hav'nt. Coke is a dull black substance something like coal, but not quite the same. It is lighter than coal and full of small holes, that is, it is porous. It is more difficult to set on fire than coal. It burns with little or no flame, but gives off intense heat, with very little smoke. Coke is used for heating and cooking, but its chief use is in the manufacture of iron and steel.

Coke is made from coal simply by piling the coal in a heap in the open or between two brick walls and setting it on fire. The outer layer of coal burns away and the heat passes to the inside of the heap and drives off the gases which are in the coal. After a time the fire simply smoulders and the heap is then raked out and quenched with water. In this way the coal is converted into coke. This method has been used in India for many years, but it is a very wasteful way of making coke. All the gases, from which many valuable things could be made, are burnt or driven off into the air and lost. Another method is to make the coke in brick ovens. The oldest oven of this kind is known as the *bee-hive coke-oven*, so called from its shape.

The coal is placed in the oven, and set on fire. Only as much air is allowed to enter the oven as will burn the gases given off from the coal. Some of the

coal also burns. After the heap of coal has been burning for about three days the door of the oven is opened and the coke raked out. It is then quenched with water. The water improves the quality of the coke. A very good kind of coke is made in the bee-hive oven. The method has the same drawback, however as the "open" method, namely that nothing can be made from the gases. It takes three tons of coal to make two tons of coke.

The modern method of making coke is to convert the coal in long narrow brick chambers. The air is entirely excluded from the chambers and the coal is not set on fire at all. The heat necessary to change the coal into coke is got from coal-gas which is burned in narrow passages (flues) running along the sides of the coking chamber. The coal-gas is itself got from the coal in the process of coking. The coal to be coked is first of all crushed into small pieces. In some cases it may even be washed with water to remove the stone and clay, for the dirtier the coal, the poorer is the quality of the coke which is made. The small coal is then dropped into the coking chamber through a hole in the top of it. A levelling ram now spreads out the coal in the chamber which is then sealed up and the gas burners lit in the side flues. The process of coking in this way takes less time than with the bee-hive oven. The coke is now pushed out by a ram on to a sloping bench. As it is pushed out of the oven in a red-hot state it is quenched with jets of water. In the oven the coke is in a solid lump but it breaks up into pieces when pushed out. There are often fifty or more of those coking ovens side by side in a row. The gases driven off from the coal, as it is being coked, pass into a large pipe. In modern coking plants the gases are not lost. The number of things that can be taken from coal is simply wonderful. As the gas passes along the pipe it cools. It is then

passed through cooling tanks. First of all tar is taken out, then ammonia liquor, then various kinds of oil. Tar, oil, and dye, explosives, artificial manure, perfumes, inks, varnishes, etc., all these and more are made from coal. Indeed it is quite impossible to describe here the hundred and one things that are taken out of the gases driven off from the coal during coking. Fig 23 shows a picture of some of these

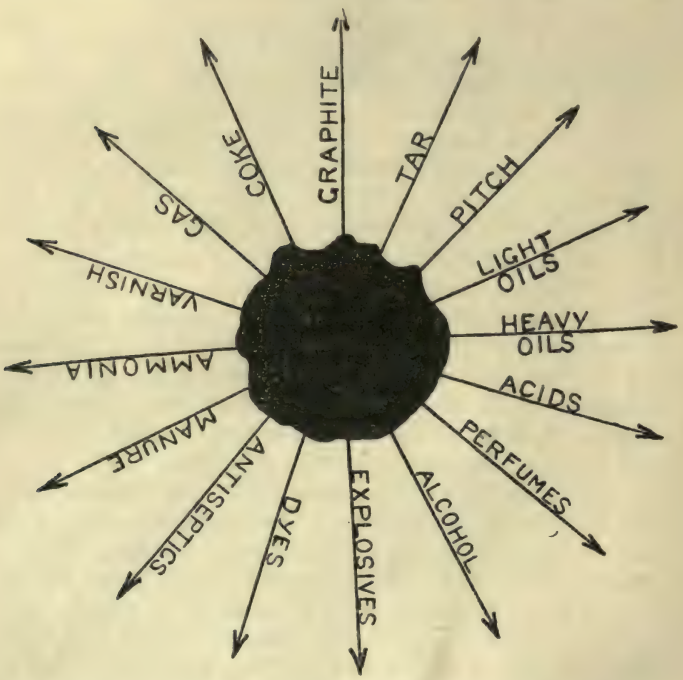


Diagram showing some of the valuable things got from coal. Fig. 23.

"bye-products" as they are called. In the simple methods of making coke which are mentioned at the beginning of this chapter all these very valuable bye-

products are lost. It is only in modern coking that the full value of the coal is obtained. You can see these modern coking plants at several places in the Jharia and Raniganj coal fields. Of course, sometimes, it does not pay the coal company to take out all the bye-products. In such cases only some of the bye-products are obtained and the rest are allowed to escape. You must also clearly understand that it would not do to try and coke all the coal. Some kinds of Indian coal are quite useless for making coke, others make very good coke indeed.

Now let us learn what is done with the gas itself, for you must know that the tar, oils, dyes, etc., are taken out of the gas, and that when everything else of value has been taken out, the purified gas remains. This gas is not worthless by any means. Indeed it is this gas which provides the heat for coking. It is taken back in pipes to the coking ovens. There it is burnt in the side flues in the way we have already described. There is generally more gas than what is required for the process of coking, and it is often a problem what to do with the surplus. One way of making use of the extra gas is to burn it in the furnaces of steam boilers. In this way steam is raised without the use of coal.

In some cases only the slack, or small coal is used for coking. In this way it is rendered more valuable than it would be in the raw state. The slack is often washed before coking so as to get rid of as much as possible of the dirt. Small stones and dirt in the slack go into the coke and reduce its value. It pays, therefore, to get out the dirt before coking.

Another thing of interest is that it often pays to mix two kinds of coal before coking. In this way the coke obtained often brings a better price than that got from the two kinds of coal made into coke separately. Or it may be, the poorer kind would

not make coke at all by itself. The iron and steel industry of India depends on a sufficient supply of good coke, so you can see that for this reason alone it is important that coke should be made. Besides, as we have pointed out, many other valuable things are obtained from the coal that would otherwise be lost. There is a great future before the coking industry in India.

CHAPTER XVI.

PREPARING, LOADING AND DESPATCHING THE COAL.

We have now learned where the coal is found, and how it is mined and been told about some of the things that can be made from it. As a fitting end to the story of the mine, let us see how the coal is prepared for and despatched to the market. The coal is not all of the same quality. Some is more suitable for steam raising than others. One way of classifying the coal is to call the best kind "First Class" coal, the next best "Second Class" and so on. A mine may be working a first class coal-seam and a second class one at the same time. The two kinds of coal must be kept separate, for of course a better price is got for the better class of coal. Sometimes dishonest people mix the poorer kinds of coal with the best quality and in this way try to get the highest price for second-rate or third-rate coal. Sometimes they manage to cheat without being found out but sooner or later some one discovers the dishonest practice. The coal is then often returned and future orders cancelled. In these cases it is often found that honesty would have been the better policy. Coal got from the same seam may often not be of the same quality. Nearly all coal seams have leaves or layers of poorer coal mixed with the good fuel. In such a case as this it may pay to keep the good coal separate from the poorer kind.

Then again the coal is not all of the same size we may get "lump" coal or we may get slack. The slack is the very small coal and it does not fetch such a good price as the "lump" does. At most collieries the slack is separated from the lump chiefly at the surface. The coal is passed over a riddle or *screen* formed of wires crossing each other or over a steel plate punched with small holes. The slack falls through the holes and the "lump" coal slides down the screen to fall clear of the slack. At a modern colliery a proper screening plant is used for this purpose. The screens are shaken to and fro by machinery and in this way a much better separation is obtained. Sometimes revolving screens are used. The miner often does some of the separation himself. He puts the slack on one side as it is made. He is paid more for the lump coal than for slack. *Tipplers* are used for emptying the loaded trams. The tram is pushed on to the tippler, which revolves and turns the tram upside down, so discharging the load of coal on to the screen.

The coal is sometimes separated into more than the two sizes mentioned, namely "lump" and slack. To do this the screens are arranged as follows :—First comes the screen with the smallest holes. As the coal passes over this screen, the fine slack passes through and the rest of the coal travels on to the second screen. This screen has larger holes and allows only small pieces, say, about the size of marbles to pass through. The third screen may sort out the pieces about the size of a golf ball, and so on. The "lump" coal passes out at the end of the row of screens. In this way you see, the coal can be separated into as many sizes as you please.

Sometimes the coal is made to pass over a "picking" belt which moves very slowly. As the coal moves slowly along any pieces of stone which may be mixed

with the coal are picked out. The selling price of the coal is increased by this process, for no one would pay a high price for coal containing stones. "Dry-cleaning" of this kind is only suitable for getting rid of the larger pieces of stone. If it is desired to take out the finer or smaller dirt particles, wet-cleaning has to be used. *Coal-washing* is not done at many Indian collieries, but there are a few places where it is carried out. It is only used for small coal, the purpose being to get rid of the dirt. The coal and dirt are separated by the action of water. The water is caused to rise and fall very rapidly by the movements of a piston. The slack, being washed, lies on a screen and the up and down surge of the water separates out the dirt from the coal very completely. In this way we get clean coal. Other kinds of coal-washing machines are used but in all of them water is used to clean the coal.

The coal is taken from the coal-field to all parts of India. Some even goes as far as Singapore and Egypt. The railways use a very large portion of the coal. Orders are placed with various coal companies, sometimes for years ahead. A certain price is paid but the coal supplied must be up to the required standard. The railways employ special officers for the purpose of watching over the quality of the coal. If the coal in any wagon is found to be below the standard, that wagon may be rejected. A good deal of the coal goes to factories and mills, such as, for instance the great jute mills of Calcutta and the cotton factories of Bombay. Some goes to engineering works, some to steamships, some to coke works and some to electricity power stations. A large quantity of coal is used at the coal mines to raise steam. A good deal is also used for household purposes such as cooking and heating. Quite a lot of coal, too, is carried away by the miners when they

return to their homes after the day's work. In colliery districts you may often see the women trudging homewards in the late afternoon with baskets of coal on their heads. Some have to walk miles to their homes. They are allowed to take the coal as a kind of "backsheesh". They certainly well deserve to get the coal for nothing when they willingly carry their self-imposed load such a long way. Where the coal has to be taken not more than a few miles it is carried on bullock-carts. On the roads leading to and from a colliery you may see long strings of bullock-carts dragging their slow weary way over the roads.

But the chief way of despatching the coal is to load it into wagons. Most of the large coal mines have railway sidings of their own. The wagons are brought into the sidings and loaded by coolies from coal heaps lying alongside the railway. Fig. 24. In more modern methods of loading, the coal passes over screens straight into the wagons. The loaded wagons may be taken almost anywhere in India, for your country as you know, is covered with a network of railways. Sometimes a colliery may not get as many wagons as it needs to despatch all its coal. The railway companies divide out their wagons amongst the collieries, but sometimes it is not possible to provide as many as are required. The growth of coal mining in India depends very largely on the railways. There are many large and valuable coal-fields in India which have hardly been touched as yet simply because there are no railways near at hand. It is not too much to say that the two things which have most effect on the growth of the industries of India are coal and the railways. Coal may be likened to the food which supplies our bodies with heat and energy, for it supplies the energy which drives most of our mills, factories and workshops. The railways



Loading a railway wagon with coal. Fig. 24.

may be likened to the blood-vessels in our bodies, which carry life and energy to every part, for they bring the coal from the mines to wherever it is required.

We have now finished our story about coal and the coal mine, and we hope it has been interesting. No one is a true patriot who does not take a keen interest in those things which vitally affect the welfare of his country. It is your duty, therefore amongst other things to learn something of the "black diamond" as coal has been so fitly called. Coal is one of the natural sources of the wealth of our great country. To know something of coal, where it is found, how it is worked, and what it can do, should be at once an education and a pleasure. May India flourish through her boundless resources and the love and patriotism of her sons and daughters !

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